EVALUATION OF DIET ADAPTATION PROGRAMS

AND SUPRANUTRITIONAL DIETARY

ANTIOXIDANTS FOR FEEDLOT CATTLE

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NOMENCLATURE

ADF	acid detergent fiber
ADG	average daily gain
ATP	adenosine triphosphate
BRD	bovine respiratory disease
BW	bodyweight
BWDGS	corn and sorghum wet distiller’s grains with solubles
CP	crude protein
CDDGS	corn dry distiller’s grains with solubles
CWDGS	corn wet distiller’s grains with solubles
D	day
DDGS	dry distiller’s grains with solubles
DG	distiller’s grains without solubles
DGS	distiller’s grains with solubles
DM	dry matter
DMI	dry matter intake
DRC	dry rolled corn
FGC	fine ground corn
G:F	average daily gain:dry matter intake
HMC	high moisture corn

HCW	hot carcass weight
IU	international unit
LM	*longissimus* muscle
LMI	limited maximum intake
ME	metabolizable energy
Mo	month
MM	multiples of maintenance
NEg	net energy for gain
NDF	neutral detergent fiber
NRC	National Research Council
PF	programming feed intake
PUFA	polyunsaturated fatty acids
SFC	steam-flaked corn
SDDGS	sorghum dry distiller's grains with solubles
SWDG	sorghum wet distiller's grains
SWDGS	sorghum wet distiller's grains with solubles
WC	whole corn
WCGF	wet corn gluten feed
WDG	wet distiller's grains without solubles
WDGS	wet distiller's grains with solubles
Wk	week
VFA	volatile fatty acid
YG	Yield grade

CHAPTER I

INTRODUCTION

Consumers look for bright cherry red beef products in the retail case as an indicator of quality and freshness (Liu et al., 1995). This visual appearance is of upmost importance as it strongly influences consumer purchasing decisions. When consumers cannot find their “ideal” beef product from a visual perspective, they either choose a different, potentially less expensive, beef product or substitute for an alternative protein source. It has been estimated by Shaefer (2002) that U.S. retailers fail to capture at least one billion dollars of revenue annually from fresh beef sales resulting from product discoloration. This discoloration is a result of beef pigment oxidation, which is positively correlated to lipid oxidation (Hutchins et al., 1967; Greene 1969). The expansion of ethanol production has led to the by-product, distiller’s grains with solubles, being fed in cattle finishing diets for a variety of nutritional and economic reasons. It has been shown that when cattle are finished on high inclusion levels of distiller’s grains with solubles, beef carcasses have increased total polyunsaturated fatty acids and the potential for increased lipid and pigment oxidation (Gill et al., 2008; Depenbusch et al., 2009; de Mello Jr., 2010; Koger et al., 2010). This dietary consequence on harvested beef has the economical potential to dwarf existing estimates of product loss due to discoloration.

However, dietary supplementation of vitamin E has been successful in delaying beef discoloration in corn-based finishing diets, yet the antioxidant and feedlot performance effects of vitamin E supplementation in finishing diets containing distiller's grains with solubles is unknown.

With the present-time high machinery, labor, and operational costs in the feedlot, maximization of operational efficiency must be of priority. The adaptation period of feedlot cattle to high-concentrate finishing diets is crucial for subsequent performance and health (Brown et al., 2006). Adaptation of the rumen requires small increases in concentrate over a period of three to four weeks in order for microorganism populations to adjust to a changing substrate and lower pH environment. Traditionally, adaptation to high-concentrate diets has been accomplished by the use of step-up diets (increasing grain and decreasing roughage through multiple diets; Krehbiel et al., 2006). However, increasing the number of adaptation step-up diets causes increased number of loads, small load sizes, increased feeding times, and lack of finished feed storage (Milton, 2009). Vasconcelos and Galyean (2007) reported that in their survey, responding consulting nutritionists used an average of 3 step-up diets to adapt cattle to finishing diets in their practices. Two-ration blending involves feeding a high and low-concentrate diet at differing proportions throughout the adaptation period, and rather than mixing the two diets in a delivery truck, the two diets are fed at separate times during the day. This results in only 2 rations to be milled and fed, and thus, has the capability to improve operational efficiency. Using this method of adaptation causes small feed calls at the beginning and end of the adaptation period and makes feed distribution and feeding timing very important (Milton, 2009). Two-ration blending also assumes that each calf in a pen will consume a diet that is in the same proportion as the 2 rations fed to the pen. The increased management and potential problems associated with two-ration blending may be the cause of why this practice was only used by 6 of 29 consulting nutritionists (Vasconcelos and Galyean, 2007).

The objectives of the experiments presented herein include: 1) Evaluate the effects of supranutritional vitamin E supplementation in wet distiller's grains with solubles finishing diets on feedlot performance and carcass characteristics; and 2) Compare feedlot performance, feed intake variation, and carcass characteristics of cattle adapted to a high-concentrate finishing diet using two different adaptation programs.

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CHAPTER II

REVIEW OF LITERATURE

VITAMIN E IN DISTILLER'S GRAINS DIETS

Feedlot performance with distiller's grains

The staggering expansion and maturation of the ethanol industry in the United States has brought substantial change to the livestock industries. The United States ethanol industry produced 175 million gallons of ethanol in 1980 (RFA, 2010). Boosted by the federal biofuels mandate and blending incentives, 2009 production was a record 10.6 billion gallons of ethanol (RFA, 2010). With each bushel of grain feedstock fermented in the production of ethanol, one third of the original cereal grain is returned to the animal feed market in the form of distiller's grains with (**DGS**) or without solubles (**DG**). Since the starch is fermented in the ethanol production process, all of the fiber, protein, fat, and minerals are returned to the DGS in a 3-fold increased concentration (Klopfenstein et al. 2008). This results in an animal feed that is high in CP (30.1%), fat (12.8%), P (0.85%), NDF (30.9%), and S (0.58%) (nutrient concentrations for wet DG (**WDG**), Dairy One Laboratory, 2010). DGS is used as an energy source when fed above 15-20% of the diet (DM basis), and consequently protein and P is fed above animal requirements (Klopfenstein et al., 2008). True proteins fed in excess of requirements are used for energy by deamination and subsequent excretion of urea. Although energy is needed for urea synthesis, Huntington and Archibeque (2000) suggest that 1 to 4 mol of ATP is required for each mol of urea and that the overall change in ME use is difficult to detect. Regardless, animal performance, available supplies, energy and protein concentration, and the price relative to corn have caused the substitution of DGS for feed ingredients across the livestock industries.

Due to the appealing qualities of DGS to the cattle feeding industry, it has been heavily studied as a feed ingredient in feedlot cattle finishing diets. Klopfenstein et al. (2008) completed a meta-analysis utilizing nine experiments with feedlot finishing diets where wet DGS (**WDGS**) replaced dry rolled corn (**DRC**), high moisture corn (**HMC**), or a combination of DRC and HMC. They showed quadratic responses to ADG and DMI with both performance variables maximized when WDGS was fed at approximately 30% of the diet (DM basis). Feed efficiency tended to be quadratic and was maximized with WDGS between 30-50% dietary inclusion (DM basis). Feeding values calculated from G:F were decreased as WDGS inclusion level increased. The authors noted that G:F values did not decrease at the higher inclusion levels, but feeding values decreased due to accounting for WDGS inclusion level in the feeding value calculation (calculated from G:F relative to control, then divided by WDGS inclusion; Klopfenstein et al., 2008). Likely due to increased ADG, cattle fed WDGS were fatter with equal days on feed compared to corn-fed control cattle. Statistically, rib fat and quality grade increased quadratically as WDGS dietary inclusion increased (Klopfenstein et al., 2008).

Klopfenstein et al. (2008) also conducted a meta-analysis of five experiments with dry DGS (**DDGS**) replacing corn in high-concentrate finishing diets. They reported a quadratic ADG response to increasing DDGS levels, with maximum ADG with diet inclusion between 20 to 30% DDGS (DM basis). There was a cubic G:F response with maximum efficiency between 10 to 20% DDGS. Comparing the WDGS and the DDGS meta-analyses, WDGS had higher feeding values at equal diet inclusion levels. Klopfenstein et al. (2008) noted this observation but had no clear drying effect explanation.

Commercial feedlots employ different corn processing methods (Galyean and Vasconcelos, 2007). Vander Pol et al. (2008) studied 30% WDGS (DM basis) in either whole corn (**WC**), DRC, 1:1 DRC:HMC blend, fine ground corn (**FGC**), or steam-flaked corn (**SFC**) diets. Dietary corn was included at 61.4% of the diet (DM basis). Vander Pol et al. (2008) reported that SFC, FGC, or WC was not as effective as HMC or DRC in cattle finishing diets with 30% WDGS inclusion (DM basis). Corrigan et al. (2009) conducted an experiment utilizing corn WDGS at diet inclusion levels of 0 (with no added supplemental fat), 15, 27.5, and 40% (DM basis) in DRC, HMC, and SFC-based finishing diets. Corrigan et al. (2009) reported a corn processing × WDGS inclusion level interaction for shrunk final BW, carcass adjusted final BW, ADG, and G:F. The response for shrunk final BW, carcass adjusted final BW, and ADG was linear in DRC-based diets, quadratic in HMC-based diets, and quadratic in SFC-based diets. The 15% WDGS treatment fed in the SFC-based diets and the 15 and 27.5% WDGS treatments in the HMC-based diets maximized ADG. For G:F, the authors reported a linear response in DRC and HMC-based diets, but no effects for SFC-based diets.

Ethanol and resulting DGS can be produced from fermentation of many cereal grains or combination of grains based on regional availability and price. This results in sorghum being utilized as a principle feedstock for ethanol plants in more arid climates. DGS from sorghum is usually higher in CP, lower in fat, and higher in ADF compared to DGS from corn (May et al., 2010a; Al-Suwaiegh et al., 2002). Lodge et al. (1997) reported similar feed efficiencies with sorghum WDG (**SWDG**) or WDGS (**SWDGS**) fed at 40% diet inclusion (DM basis) compared with a DRC-based control. The cattle fed a fourth treatment, sorghum DDGS (**SDDGS**) at 40% of the diet (DM basis), were less efficient than all other treatments. The NEg values based on cattle performance of SWDG, SWDGS, and SDDGS were 96, 102, and 80% relative to corn, respectively (Lodge et al., 1997). When fed at 30% of the diet (DM basis), Al-Suwaiegh et al. (2002) reported NEg values for CWDGS and SWDGS to be 33.3 and 24.7% greater than the NEg value of DRC.

May et al. (2010a) evaluated 0% DGS (control), 15% SWDGS, 30% SWDGS, 15% CWDGS, 30% CWDGS, 15% 1:1 blend of SWDGS:CWDGS (**BWDGS**), and 30% BWDGS in SFC-based finishing diets. Diets were formulated to contain equal concentrations of ether extract. ADG was numerically greatest for control cattle. Statistically, ADG was greater for SFC-fed control cattle compared to the average of all the WDGS treatments. They observed decreased carcass adjusted final BW, HCW, and G:F as the level of WDGS diet inclusion increased. Net energy values calculated from cattle performance were greater for CWDGS than for SWDGS, with BWDGS being intermediate. Inclusion of 15% WDGS compared with 30% WDGS also improved NE values.

The results of May et al. (2010a) disagree with many aforementioned DGS feedlot performance trials. The authors noted that these contrasts are presumably the result of differences in type of WDGS fed (SWDGS or CWDGS), plant to plant variation in product, and corn processing methods. Zinn (1989) researched the energy value of lipid in feedlot finishing diets. Differences in performance variables across trials comparing DGS to control diets is likely due to experimental differences in only replacing corn with DGS or also balancing diets for ether extract. Although differences exist in DGS performance trials, it would be hard to dispute the regional availability of DGS, positive ration conditioning of WDGS, the cost effectiveness of DGS protein, or the substantial influence the ethanol industry has had on the feedlot industry.

Vitamin E supplementation in feedlot diets

Extensive data in the literature has been compiled for receiving and feedlot cattle studying levels of vitamin E supplementation through dietary or systemic routes of administration and with or without selenium. Both a meta-analysis (Cusack et al., 2009) and a review (Secrist et al., 1995) of vitamin E supplementation in growing and feedlot diets have been published. Experiments conducted have analyzed feeding very high levels of vitamin E for a short duration prior to harvest to feeding more moderate levels (still in excess of NRC (2000) requirements) for longer durations prior to harvest. Overall, results from the studies on feedlot cattle have been variable and inconsistent.

Garber et al. (1996) investigated supplementing vitamin E to beef and Holstein steers fed a ground corn-based finishing diet which provided each steer with a daily basal vitamin E amount of 167 IU. Steers were supplemented vitamin E at treatment levels of 0, 250 (beef steers only), 500, 1,000, and 2,000 IU$\cdot$steer$^{-1}\cdot$d^{-1}. Cattle were fed treatment diets for a range of 119 to 153 d. Garber et al. (1996), agreed with the aforementioned studies by Arnold et al. (1992), finding no vitamin E supplementation treatment effects on feedlot cattle performance.

In an experiment performed by Secrist et al. (1995), steers were finished on a 92% concentrate HMC-based diet and supplemented with either 100 or 300 IU·steer^{-1}·d^{-1}. Steers were fed treatment diets for 145 d. They reported numerical increases in ADG and DMI and a tendency for improved feed efficiency with the 300 IU of vitamin E supplementation. Hill et al. (1995) reported yearling steers supplemented for 105 d with 1,500 IU·steer^{-1}·d^{-1} vitamin E compared to 150 IU·steer^{-1}·d^{-1} had improved ADG of 9.8% and feed efficiency of 3.7%. Conversely, in another study in the same report with the same treatment levels but fed for 133 d, there were no performance effects.

Rivera et al. (2002) supplemented vitamin E at approximately 285, 570, and 1,140 IU·animal^{-1}·d^{-1} to lightweight steer and bull calves (experiment 1) and heifer calves (experiment 2). They fed the treatment diets for a 28 d receiving period, after which all cattle were subject to a growing program (196 d for experiment 1; 164 d for experiment 2). All cattle were then finished, over 91 d for experiment one and 98 d for experiment two, on a 90% concentrate SFC-based diet that was formulated to provide vitamin E at 133 IU·animal^{-1}·d^{-1}. They observed no differences in BW for either experiment. During the finishing period, they reported greatest DMI and numerically highest ADG for the steers previously fed the 570 IU·steer^{-1}·d^{-1} treatment receiving diet. However, in the heifer study, they did not find performance or intake differences.

A meta-analysis was performed on the health and production effects of supplemental vitamin E of feedlot cattle by Cusack et al. (2009). These researchers used a range of receiving and finishing studies, varying in vitamin E supplementation level and duration. Due to vitamin E supplementation, they observed 2 of 12 trials to increase ADG, 2 of 11 trials to significantly improve DMI, and 2 of 11 trials to improve G:F. Morbidity was improved by vitamin E supplementation in 1 of 6 trials, and treatment costs were lowered in 1 of 2 trials. As a result, Cusack et al. (2009) concluded that injectable or dietary vitamin E supplementation above NRC (1996) recommendations does not improve the performance variables of ADG, G:F, or morbidity of feedlot cattle.

Secrist et al. (1997) conducted a review of 21 feedlot performance trials evaluating the effects of vitamin E supplementation on feedlot cattle performance. These trials ranged in vitamin E supplementation level from 74 IU·animal^{-1}·day^{-1} to 2,000 IU·animal^{-1}·day^{-1} fed for 38 to 298 d with corn silage, DRC, or HMC-based diets. They reported an increase in ADG of 2.9%, no improvement in DMI, and consequently a 1.8% increase in feed efficiency. They concluded from the review that the variability of results may be dependent on supplementation level, previous nutritional background, vitamin E status of the cattle at the start, stress level of the cattle, and vitamin E content of the basal diet (Secrist et al., 1997).

Antioxidant effects of vitamin E in DGS diets on meat quality

Beef consumers prefer wholesome, high quality beef (Roeber et al., 2005), and this preference drives consumer demand and ultimately, profit potential throughout the entire beef industry. According to Liu et al. (1995), visual appearance is the most significant characteristic influencing consumer purchasing decisions. Meat cuts that lack a fresh appearance are usually discriminated and later discounted at the retail level.

Beef color is composed of three pigments, deoxymyoglobin, oxymyoglobin, and metmyoglobin (Renerre and Labas, 1987). Deoxymyoglobin is present with fresh cut meat and is purplish in color. When deoxymyoglobin is exposed to oxygen, the pigment oxymyoglobin is formed which is bright cherry red. When meat begins to ‘fade,’ the brown color associated with consumer unacceptability is due to myoglobin oxidation to metmyoglobin (Renerre and Labas, 1987). In metmyoglobin formation a molecule of water substitutes for oxygen. The heme iron is thus in the ferric form (Fe^{3+}) in metmyoglobin, whereas the heme iron is in ferrous form (Fe^{2+}) in both deoxymyoglin and oxymyoglobin (Liu et al., 1995). There are many factors affecting metmyoglobin formation (Okeefe and Hood, 1982; Ledward, 1985; Liu et al., 1995). Lipid oxidation has been shown to be positively correlated with pigment oxidation (Hutchins et al., 1967; Greene 1969). Liu et al. (1995) believes that the production of radical species during lipid oxidation may act directly in promotion of pigment oxidation or indirectly by damaging pigment-reducing systems. Oxidation of unsaturated lipids also produces offensive odors and flavors and can decrease the nutritional quality and safety in food after cooking and processing (Frankel, 1980).

There is evidence that feeding DGS to finishing cattle increases polyunsaturated fatty acids (**PUFA**) in beef (Gill et al., 2008; Depenbusch et al., 2009; de Mello Jr., 2010; Koger et al., 2010). Depenbusch et al. (2009) showed increased PUFA concentrations in one of two studies in the same report comparing varying levels of CWDGS, CDDGS, SWDGS, or SDDGS. Interestingly, Depenbusch et al. (2009) reported higher concentrations of PUFA in carcasses that were fed corn DGS treatments compared to that of sorghum DGS treatments. Similarly, Brandt et al. (1992) reported greater concentrations of the unsaturated fatty acid linoleic acid in steaks from corn-fed steers compared to sorghum-fed steers. This correlated directly to higher linoleic acid in steam-flaked corn diets than steam-flaked sorghum diets.

Koger et al. (2010) studied the effects of feeding various quantities of WDGS and DDGS to feedlot steers on carcass characteristics, meat quality, retail case-life of ground beef, and fatty acid profile of *longissimus* muscle (**LM**). Wet distiller's grains with solubles or DDGS was added to the diet at inclusion levels of either 20 or 40% (DM basis), which replaced all of the soybean meal and part of the DRC formulated in the control treatment diet. Distiller's grains with solubles treatment carcasses had greater fat thickness and USDA Yield Grades (**YG**) with a smaller percentage of USDA YG 1 and 2. *Longissimus* muscle from cattle fed DGS had less C17:0 and more C18:0, C18:1*t*, C16:1*c*9, C18:2*c*9*c*12 (where *c* is *cis* and *t* is *trans*), and total PUFA compared with control treatment LM. Kinman et al. (2010) also observed increased PUFA and n:6 fatty acids when comparing their higher concentrations of WDGS (20 and 30% inclusion; DM basis) to 10% WDGS inclusion in a SFC-based finishing diet. The control SFC treatment (0% WDGS) had numerically intermediate PUFA concentrations (Kinman et al., 2010). However, these authors agreed that beef from cattle finished on diets utilizing higher inclusion rates of DGS (>20% on a DM basis) will likely have increased PUFA, and subsequently, be more susceptible to oxidative rancidity.

It has been discovered that dietary vitamin E can delay metmyoglobin formation in fresh meat cuts. Arnold et al. (1992) conducted three experiments using differing vitamin E supplementation levels and durations in HMC-based finishing diets. In experiment one, Holstein steer calves were supplemented with vitamin E at 0 or 500

IU·steer^{-1}·d^{-1} for 9 mo prior to harvest. Experiment two supplemented beef steers at 0 or 2,000 IU·steer^{-1}·d^{-1} for a period of 67 d prior to harvest. Experiment three supplemented Holstein steers at 0 or 2,000 IU·steer^{-1}·d^{-1} during the last 38 d prior to harvest. Lipid oxidation was decreased and metmyoglobin formation was delayed with vitamin E supplementation. They reported that vitamin E supplementation, either by long, low dosage or short, high dosage, extended the color stability of fresh beef displayed during simulated retail display. They did note that vitamin E supplementation had a more profound effect on meat from Holstein steers.

de Mello Jr. et al. (2010) conducted a study supplementing vitamin E at 0 (**0E**), 100 (**100E**), 300 (**300E**), 500 (**500E**), and 1,000 (**1,000E**) IU·steer^{-1}·d^{-1} in a 35% WDGS (DM basis) finishing diet. A corn control was also fed and all diets were based on a 1.5:1 ratio of HMC:DRC. Cattle were fed experimental diets for all 128 d on feed. These researchers observed that the treatments of 1,000E, 300E, and control had similar but significantly superior lipid stability compared to 500E, 100E, and 0E. Oxidation of *Longissimus dorsi* steaks was delayed the most with the 1,000E treatment, the least for the 0E treatment, with control being intermediary. These results suggest that vitamin E supplementation can help counteract the aforementioned retail shelf life shortcomings of DGS-fed beef.

Vitamin E supplementation benefit in the beef industry

From an economic standpoint, the beef industry could reap valuable benefits by feeding supplemental (supranutritional) levels of vitamin E to finishing cattle. There have been many economic analyses done studying the effects of supranutritional levels of dietary vitamin E on the subsequent beef value retained through retail case-life extension.

The cost of supplementing vitamin E at 500 IU daily for 100 d or more has been reported at $1.43 to $4.00 per finished animal (Morgan et al. 1993; Liu et al., 1995; Westcott et al., 2000). Hermel et al. (1993), as cited by Smith et al. (1996), calculated a benefit to cost ratio of 8:1. This is similar to the 10.4:1 ratio calculated by Liu et al. (1995). Based on volatility in market values, costs and benefits of implementing vitamin E supplementation are ever changing, yet the trend of increased returns above costs for the entire beef industry have remained constant.

Even with the calculated economic benefit to the production of retail beef, feeding supranutritional levels of vitamin E in beef finishing diets has not been widely adopted. The beef industry is segmented and not integrated like competing animal protein industries. Whereas the cost of supplementation would fall to the cattle feeder, the economic benefit would be realized at the retail level. Also involved in the complexity of this issue is the question of whether or not vitamin E supplementation at agreed upon levels occurred during cattle finishing. However, methods of validation include sampling finishing diets or sampling neck muscle after harvest (Shaefer, 2002) and measuring vitamin E concentrations. Shaefer (2002) reported that 15% of fed cattle marketed annually in the United States and Canada were receiving supplemental vitamin E to target retail marketability of fresh beef. This cooperation between the multiple segments has been arranged through marketing alliance formation. Growing beef export demand, growing perception of meat quality issues from DGS-fed beef, and the ever narrowing margin of beef production should undoubtedly warrant present day investigation of supplementation of vitamin E to finishing cattle at supranutritional levels.

ADAPTATION OF FEEDLOT CATTLE TO HIGH-CONCENTRATE DIETS

Feedlot finishing diets are formulated with high concentrations of grain (Vasconcelos and Galyean, 2007). Roughages in feedlots pose mixing and handling problems, and therefore, minimizing forage inclusion improves operational efficiencies of feedlot mills (Brown et al., 2006). However, prior to feedlot entry, cattle are typically fed forage-based diets. In order to effectively use readily fermentable carbohydrates found in high-concentrate diets, ruminal microorganism populations must adapt to changing substrate and a lower pH environment or a host of metabolic disorders will precipitate (Brown et al., 2006). Roughage in high-concentrate diets is fed to maintain rumen health and to control acidosis (Nagaraja and Lectenberg, 2007). Feedlot managers and nutritionists must balance the costs of forage inclusion and reduced dietary energy density with the potential problems associated with feeding low roughage finishing diets. In the survey of feedlot consulting nutritionists conducted by Vasconcelos and Galyean (2007), they reported that none of the respondents (n = 29) formulated for more than 90% grain. However, roughage inclusion rates that seem very low by industry standards and even no roughage in finishing diets have been studied. Turgeon et al. (2009) suggests that roughage-free finishing diets must be carefully formulated to mitigate digestive disturbances and optimize feedlot performance.

Acidosis

The second leading cause of morbidity and mortality in feedlot cattle is digestive disturbances (Nagaraja and Lectenberg, 2007), and acidosis is the most common digestive tract disorder for ruminants fed high-concentrate diets (Owens et al., 1998). Acidosis, as defined by Stedman (1982), is a decrease in the alkali in body fluids relative to the acid content. In feedlot cattle, ruminal acidosis is caused by rapid ingestion of readily fermentable carbohydrate, but metabolic acidosis can occur when large concentrations of organic acids produced from ruminal fermentation enter the blood and decrease blood pH. Acidosis has been characterized by ruminal pH with benchmarks of 5.6 and 5.2 used to differentiate subacute and acute acidosis, respectively (Cooper and Klopfenstein, 2006). The visual symptoms of acidosis include anorexia, diarrhea, mucus in feces, dehydration, incoordination, and death (Elam et al., 1976). These signs become apparent 12 to 36 h post-grain engorgement (Nagaraja and Lectenberg, 2007). Ruminal acidosis can cause many secondary feedlot ailments such as laminitis, rumenitis, liver abscess, and polioencephalomalcia (Brent, 1976) along with feedlot bloat (Cheng et al., 1998) and decreased animal performance (Nagaraja and Lectenberg, 2007).

The etiology of acidosis has been well studied and reviewed (Owens et al., 1998). During ruminal acidosis, bacterial populations of starch and soluble sugar fermenting species grow rapidly with plentiful substrate in the rumen. The bacteria most commonly associated with an acidosis bout include *Selenomonas ruminantium, Streptococcus bovis,* and *Lactobacilli* species. These species ferment starch and soluble sugars to volatile fatty acids (**VFA**) and DL-lactic acid. *Streptococcus bovis* is especially dangerous, as this species grows extremely rapidly in the presence of excess fermentable carbohydrate and can tolerate low pH. Nagaraja and Lectenberg (2007) noted the role of *Streptococcus bovis* is to initiate the chain of events potentially leading to acute acidosis. At extremely low pH (<5.6), growth rate of most bacterial species is inhibited, including *Streptococcus bovis* to an extent, this allows the acid-tolerant and lactate-producing *Lactobacilli* species to become dominant in the rumen (Nagaraja and Lectenberg, 2007).

Lactate-utilizing bacteria metabolize lactate to VFA. Ruminal species that ferment lactic acid include *Anaerovibrio lipolytica*, *Fusobacterium necrophorum*, *Megasphaera elsdenii*, *Peptostreptococcus asaccharolyticus*, *S ruminantium* subsp *lactilytica*, *Propionibacterium acnes*, and *Veillonella parvula*. Lactate utilizing microbes are sensitive to low pH, whereas lactate producing microbes are not, and it is this balance of populations that determines acid accumulation (Owens et al., 1998).

Ruminal populations of protozoa also play a role in acidosis. Protozoa engulf starch particles and store glucose as polysaccharide, which slows ruminal fermentation and acid accumulation. Populations of ruminal bacteria normally decrease with the presence of protozoa, which also aids in reducing the rate of fermentation. However, Owens et al. (1998) noted that when protozoa rupture due to changes in acid or osmolality associated with acidosis, they release large amounts of amylase. This causes an increase in the rate of starch breakdown to glucose and increases the likelihood of acidosis.

Periods in which acidosis is most probable include the adaptation period to high-concentrate diets, significant weather events, the late feeding period, and a host of potential causes resulting in disruptions in normal feed intake. Management decisions during these time periods such as feeding higher roughage, lower energy diets to hungry cattle and limiting energy intake in newly received cattle is essential to lessen potential losses in cattle performance and even mortality. Daily consistency in management of feed calls and delivery are prudent. Dietary factors have significant impacts on the probability of acidosis occurrence. Level and type of dietary roughage, type and amount of cereal grain, grain processing, fat level, and feed additives, such as but not limited to ionophores, affect feed intake patterns and acidosis incidence. Along with the obvious decrease in dietary starch concentration, Nagaraja and Lectenberg (2007) believe that the addition of high inclusion levels of low starch fermentation by-products in feedlot finishing diets is the single most significant feeding change since the introduction of the ionophore monensin.

Methods of adaptation to high-concentrate diets

There have been many studies reported in the literature involving adaptation of cattle to high-concentrate diets. Literature on the adaptation period in feedlot cattle have been summarized by Krehbiel et al. (2006) and Hicks (2010). Limiting or programming feed intake of the final finishing diet has been successful (Bierman and Pritchard, 1996; Weichenthal et al., 1999; Choat et al., 2002). Xiong et al. (1991), Bartle and Preston (1992), and Holland et al. (2007) have used sequential step-up diets limited to multiples of maintenance. In addition, the use of by-product feeds low in readily fermentable starch has been used to adapt feedlot cattle to high-concentrate finishing diets (Birkelo and Lounsbery, 1993; Huls et al., 2009a; Huls et al., 2009b; Rolfe et al., 2010).

Programming feed intake (**PF**) of the final finishing diet has been successful in adapting cattle to high-concentrate diets. When PF was compared with ad libitum feeding of step-up diets to adapt yearling steers (Bierman and Pritchard, 1996; Weichenthal et al., 1999; Choat et al. 2002, Exp. 1), these researchers reported no influence on ADG, a reduction in DMI, and the resultant improvement in feed conversion. However when Choat et al. (2002) used PF to adapt steer calves, ADG, DMI, final weight, and HCW suffered compared to steers that were allowed ad libitum consumption of traditional step-up diets. The PF steer calves did not reach ad libitum DMI until between d 29 and 56.

According to Choat et al. (2002), benefits from this method of adaptation include simplified bunk management, reduced feed waste, and potential for reduced manure and nutrient output. The number of rations to be milled and fed would also be diminished over traditional step-up programs. Acidosis risk during adaptation with programming intake is undoubtedly greater than traditional step-up programs, especially in large commercial pen situations compared with small pen research as was acknowledged by Weichenthal et al. (1999).

Xiong et al. (1991) and Bartle and Preston (1992) have studied restricting access by limiting maximum intake (**LMI**) by multiples of maintenance (**MM**). Limited maximum intake treatments were designed to reduce daily variation and control peaks in DMI, yet not program or reduce feed intake (Bartle and Preston, 1992). Xiong et al. (1991) compared feeding step-up diets and the final finishing diet (either 9 or 18 % roughage equivalent) ad libitum compared with LMI (2.3, 2.5, and 2.7 × maintenance for wk 1, 2, and 3, and 2.9 × maintenance thereafter). Through d 56 of the trial, the MM regimen was beneficial for ADG in the low roughage treatments, but the ad libitum treatment had improved ADG in the high roughage treatments. Over the entire feeding period (112 d) steers fed the 18%-roughage equivalent MM treatment tended to have increased ADG over the 18%-roughage equivalent ad libitum treatment; no differences were noted between the MM and ad libitum treatments in the 9%-roughage equivalent treatments.

Bartle and Preston (1992) evaluated LMI (either 2.3, 2.5, and 2.7 × maintenance for wk 1, 2, and 3, and 2.9 × maintenance thereafter (**2.9MM**) or 2.1, 2.3, and 2.5 × maintenance for wk 1, 2, and 3, and 2.7 × maintenance (**2.7MM**) thereafter) compared with ad libitum feeding of step-up diets. During the first 28 d, LMI steers had numerically reduced DMI. Yet throughout the adaptation period, the 2.7 MM treatment cattle had a numeric increase in ADG and tended to have improved gain efficiency, the 2.9 MM treatment cattle were numerically intermediate for performance variables. They also reported that the 2.7MM treatment tended to have improved ADG and gain efficiency over the entire feeding period. Interestingly, the 2.7MM treatment also tended to have the most clumping of ruminal papillae, suggesting that reductions in digestive upsets may not have caused the performance advantages (Bartle and Preston, 1992). Also of note, as cited by Gibb and McAllister (1999), Jim et al. (1998) observed no improvements in performance by feeding barley-based diets with a limited maximum intake regimen. LMI is an easily implemented management practice that should reduce daily pen DMI variation (Krehbiel et al., 2006), and thereby, potentially improve performance.

Holland et al. (2007) conducted a study involving adaptation of steer calves to a high-concentrate, program-fed diet by using either traditional step-up diets, LMI, PF, or prolonged feeding of a receiving ration (64% concentrate for 28 d) followed by traditional adaptation (**REC**). They observed no differences in BW or ADG on d 21. However, from d 22 to 42, the REC treatment had the greatest ADG and subsequent BW, although the authors speculated that gastrointestinal fill had a partial contribution. Over the entire 60 d receiving period and after all treatments had been on a common 88% concentrate program-fed diet for 18 d, REC still had the greatest BW, followed by LMI and TRAD being intermediate, and PF having the lightest BW. This performance advantage held true for ADG over the 60 d period as well, with REC having the greatest

ADG, LMI and TRAD being intermediate, and PF having the lowest ADG. REC steers had the greatest DMI, and conversely, PF the lowest DMI. Interestingly, there were no differences in DMI for LMI and TRAD, even though by treatment definition, LMI steers were restricted to an extent and TRAD were fed ad libitum. REC steers consumed the greatest amount of ME/d, but also tended to be the least energy efficient (ME intake/d:ADG). Steers treated at least once for bovine respiratory disease (**BRD**) across all treatments was 38.7% for this experiment. Total BRD morbidity was higher for TRAD and PF steers compared to their REC and LMI contemporaries. Study-deemed chronics were greatest for PF, with TRAD being intermediate, and REC and LMI having the least.

Expansion of the ethanol industry has resulted in increased feeding of by-product feedstuffs. Research has been conducted to study wet corn gluten feed (**WCGF**; Huls et al., 2009a; Huls et al., 2009b) and DGS (Birkelo and Lounsbery, 1993; Rolfe et al., 2010) as an alternative method of adapting feedlot cattle to high-concentrate diets. These by-product feedstuffs are high in energy, protein, and fiber, but low in readily fermentable starch. Huls et al. (2009a) used 8 ruminally fistulated steers to compare a traditional step-up adaptation program (45% to 7.5% forage; DM basis) to feeding WCGF at decreasing levels (85% to 35%; DM basis). Each treatment used 4 adaptation diets (fed for 5, 7, 7, and 7 d) along with a finisher (fed for the last 7 d) over the 33 d trial. The WCGF adaptation treatment cattle had greater DMI and more meals/d than the traditional program. Average ruminal pH, minimum pH, and maximum pH were all lower for the WCGF treatment. The authors speculated that this was likely due to the increase in feed intake. Ruminal pH variance and time spent below a pH of 5.6 was greater for WCGF.

However, only 1 steer in the study was study-deemed acidotic, interestingly, it was a steer on the traditional adaptation treatment. After this study, Huls et al. (2009b) investigated using WCGF at decreasing levels compared to a traditional step-up program to adapt 240 feedlot steers to a common high-concentrate finishing diet. Cattle were adapted over a 26 d period, with 4 adaptation diets fed for 5, 7, 7, and 7 d. Steers were on feed for a total of 173 d. Final BW and HCW were greater for WCGF-adapted steers, but DMI was not different. This resulted in improved ADG and F:G for steers on the WCGF adaptation treatment. Huls et al. (2009b) noted that the feedlot industry could reduce roughage needs by 50% by decreasing WCGF instead of roughage in adaptation programs.

Rolfe et al. (2010) studied a traditional step-up adaptation program to feeding WDGS at decreasing levels. Using 8 ruminally fistulated steers, steers were adapted to a common DRC-based finishing diet using 4 step-up diets (fed for 7 d each). From d 28 until d 35, all cattle were fed the finishing diet. During the first 3 adaptation diets, these authors observed that WDGS cattle had lower DMI. However, DMI did not differ on the 4th adaptation diet or the finisher diet. Average ruminal pH was lower for the WDGS treatment steers during adaptation diets 2 and 3, but there were no pH differences once all cattle were fed the finisher. Hydrogen sulfide gas production has been shown to be increased with feeding DGS (15 and 30% of diet, DM basis; May et al., 2010b). In this experiment, the initial level of WDGS was 87.5% of the diet (DM basis) for the WDGS treatment. These authors observed no visual problems from increased dietary sulfur levels, and hydrogen sulfide gas tended to be greater for the WDGS treatment only during the second adaptation diet.

Yearling steers were used in a study conducted by Birkelo and Lounsberry (1993) to evaluate the use of WDGS fed at decreasing levels for adaptation to a DRC-based finishing diet. Using 4 adaptation diets for each treatment, hay content was decreased from 50% to 10% of the diet (DM basis) or WDGS was decreased from 43% to 0% (DM basis). The common finishing diet was fed on d 23 of the trial, and final trial weights were taken on d 28. ADG was not affected by adaptation treatment (Birkelo and Lounsberry, 1993). However, DMI was reduced by 22% for the WDGS treatment, which consequentially improved feed conversion by 23%. The authors reported no problems associated with acidosis, laminitis, or increased dietary sulfur concentrations.

The use of ionophores during the adaptation period should theoretically help mitigate acidosis and allow for a healthier rumen transition. In general, lasalocid, laidlomycin propionate, and salinomycin do not affect feed intake (Nagaraja et al., 1997). Monensin is the most prevalent ionophore used in feedlots, and feed intake is generally reduced with monensin inclusion. Nagaraja et al. (1997) suggested that the feed modulating abilities of monensin are attributable to the antimicrobial effects on ruminal fermentation along with an aversion to feed due to an adverse taste reducing palatability. The use of monensin and an accelerated step-up regimen was studied by Parsons et al. (2010). Their experiment utilized a 2 × 2 factorial arrangement with either 33 or 44 g/ton monensin (DM basis) fed for the entire 153 d trial and a 10 or 21 d step-up period. They observed no differences in feedlot performance or carcass traits due to step-up regimen, although the accelerated (10 d) step-up program resulted in the consumption of less roughage. Increased monensin concentration resulted in decreased DMI during the first 56 d and over the entire feeding period. The higher monensin concentration improved

G:F for both trial periods. These authors reported that feeding the increased concentration of monensin was most beneficial during the step-up phase of production, which agrees with a similarly designed study conducted by Burrin et al. (1988). As one would expect, cattle on accelerated step-up regimens tended to have an increase in liver abscesses (Parsons et al., 2010), but the increased concentration of monensin resulted in numerically less liver abscesses across both step-up regimens.

SUMMARY FROM THE LITERATURE

Feedlot management decisions have potential effects on live animal and economic performance, final retail value and meat quality, and feedlot operational efficiency. Cattle are grown on mainly roughage-based diets prior to feedlot entry, but the costs associated with roughage inclusion favors the feeding of high-concentrate diets in the feedlot. It is well known that an animal’s first few weeks in the feedlot and the time of adaptation to a high-concentrate diet is critical for that animal’s future health and performance. This adaptation period and the corresponding feed logistic challenges can also be of significant concern for feedlot operational efficiencies. Nutritional considerations such as the inclusion of certain dietary ingredients, feed additives, and antioxidants during finishing not only affect feedlot performance but also have significant impacts on retail value and meat quality. The experiments presented in this thesis were designed to evaluate specific feedlot management programs on finishing cattle performance and carcass measures.

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CHAPTER III

VITAMIN E SUPPLEMENTATION IN WET DISTILLER'S GRAINS WITH SOLUBLES BEEF FINISHING DIETS: FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS

ABSTRACT: An experiment was conducted to evaluate feedlot performance and carcass characteristics of finishing beef steers fed diets containing wet distiller's grains with solubles (**WDGS**) and supplemented with vitamin E. One hundred ninety-nine steers (BW = 370 ± 32 kg) of mixed *Bos indicus* and *Bos taurus* breeding were blocked by BW and randomly assigned to 1 of 4 supplemental vitamin E (**VITE**) treatment levels (0, 125, 250, and 500 IU·steer^{-1}·day^{-1}) fed for the last 97 d of the feeding period. Two blocks were on feed 129 d and 3 blocks were fed for 150 d. Steers were fed a dry rolled corn-based finishing diet with 35% WDGS (DM basis). Individual BW were measured initially on 2 consecutive d, the initial d of vitamin E supplementation, and the d of harvest. Carcass weights were collected at harvest, and carcass data were collected after a 36-h chill. Bodyweights and live weight ADG were not affected by VITE treatments ($P \geq 0.34$). Carcass adjusted final weights resulted in a linear increase ($P = 0.04$) in ADG due to increasing supplemental concentration of vitamin E. There was a related tendency for a linear (P = 0.08) increase in carcass adjusted BW due to increasing concentration of vitamin E. Pre-vitamin E and VITE period DMI were not affected ($P \geq 0.24$) by VITE treatments, but there was a trend (P = 0.08) for a linear increase in overall DMI with increasing vitamin E supplementation. No difference ($P \geq 0.29$) occurred in G:F measures using live weight gains, but G:F using carcass adjusted weight gains resulted in a numerical linear (P = 0.11) increase in G:F due to increasing concentration of vitamin E. Hot carcass weight tended (P = 0.08) to increase linearly with increasing dietary vitamin E. VITE supplementation resulted in no effects ($P \geq 0.13$) for measured carcass characteristics. Marbling scores and calculated YG were also not affected ($P \geq 0.37$). However, the distribution of calculated YG resulted in a quadratic effect (P = 0.02) for YG 3 with the control and 500 IU VITE being higher than the two intermediate levels. However the percentage of carcasses grading YG 3 or lower were not affected by vitamin E supplementation (P = 0.64). No differences were observed in the distribution of quality grades based on marbling score ($P \geq 0.57$). Data from this study suggest that vitamin E supplemented above basal requirements during the last 97 d of the feeding period in WDGS diets result in little to no impact on animal performance or measured carcass characteristics.

Key words: Carcass, Cattle, Distiller’s grains, Feedlot, Growth, Vitamin E

INTRODUCTION

U.S. ethanol production reached a record 10.6 billion gallons in 2009 (RFA, 2010). One third of each bushel of grain feedstock used for ethanol production is returned to the animal feed market as distiller's grains with solubles (**DGS**), with 30.5 million metric tons of DGS being produced in 2009 (RFA, 2010). Wet DGS (**WDGS**) have been shown to have greater feeding value than corn in cattle finishing diets, and ADG and G:F have been shown to be maximized at inclusion rates of approximately 30% of the diet (DM) in dry rolled corn (**DRC**)-based diets (Klopfenstein et al., 2008). Cattle performance, supplies, and price relative to corn makes substituting DGS for feed grains appealing to cattle feeders.

Distiller's grains with solubles-fed beef has been shown to have increased PUFA compared to beef from cattle fed traditional corn-based control diets (Gill et al., 2008; Depenbusch et al., 2009; Koger et al., 2010). Meats containing elevated levels of highly unsaturated lipids are more susceptible to lipid oxidation resulting in more rapid discounting and shorter retail case shelf life. In a review by Liu et al. (1995), vitamin E has been shown to slow this aforementioned lipid oxidation through protection of membranal unsaturated fatty acids from oxidation. This delays the oxidative change in beef pigment from oxymyoglobin to brown metmyoglobin which enhances shelf life (Wood and Enser, 1997). Vitamin E supplementation in traditional feedlot finishing diets has been subject to a review by Secrist et al. (1997) and a meta-analysis by Cusack et al. (2009), but limited cattle finishing performance and carcass data have been evaluated with vitamin E supplementation in finishing diets containing elevated levels of DGS. The objective of this experiment was to evaluate the effects of vitamin E supplementation level in a WDGS finishing diet on feedlot performance and carcass characteristics.

MATERIALS AND METHODS

Cattle

One hundred ninety nine steers (BW = 327 ± 28 kg) of mixed *Bos indicus* and *Bos taurus* breeding arrived at the Oklahoma Panhandle Research and Extension Center feedlot from wheat pasture in February of 2009. Approximately 18-h after arrival, steers were individually identified with an uniquely numbered ear tag, weighed, vaccinated against infectious bovine herpes virus-1, bovine viral diarrhea virus (types I and II), bovine parainfluenza-3, and bovine respiratory syncytial virus (Vista 5 SQ, Intervet/Schering Plough Animal Health, Roseland, NJ), dewormed with ivermectin (Ivomec Plus, Merial, Deluth, GA), and implanted with trenbolone acetate and estradiol (Revalor-XS, Intervet/Schering Plough Animal Health). After processing, steers were limit fed a mixed ration containing 62% DRC, 30% alfalfa, and 8% supplement (DM basis) that was fed at 2% of BW for 38 d before initiation of the experiment. The supplement was formulated to supply 22 mg/kg of monensin and 8 mg/kg tylosin (90% DM basis, Elanco Animal Health, Greenfield, IN).

Feeding Management

The steers were adapted to a 93% concentrate finishing diet (Table 3.1) using 3 transition diets containing 68% concentrate (12 d), 76% concentrate (5.5 d), and 84% concentrate (5 d). The final finishing diet was formulated to meet or exceed NRC (2000) nutrient requirements and contained monensin and tylosin (Elanco Animal Health; 33.5

and 10.6 mg/kg, respectively, on a 90% DM basis). Diets were mixed and fed twice daily (0730 and 1300 h) using a Roto-Mix 184-8 mixer wagon (Roto-Mix, Dodge City, KS). All pharmaceuticals and supplemental vitamins and minerals were contained in a fine-ground corn-based supplement mixed at the Oklahoma State University Animal Science Feed Mill, Stillwater. Bunks were evaluated twice daily with the goal of 0 to 1 kg of feed remaining at the morning evaluation. Dry matter determination (105°C for 5 h) was conducted weekly on WDGS samples and used to adjust as-fed ration batching. Feed bunks were cleaned and orts weighed before feeding on each weigh d and as needed to ensure feed quality. Samples of orts were dried using the aforementioned method. Dry orts were subtracted from DM delivery for determination of pen DMI. Animals were housed in open lot dirt floor pens that were approximately 36.6 × 27.4 m. Bunks were 9.1 m in length and cattle had ad libitum access to water via an automatic water basin located along the fence line and shared between 2 adjacent pens.

Experiment

Initial experiment BW were collected after the 38 d growing program. Initial BW were collected prior to the morning feeding on d -1 and d 0 of the experiment. Steers (BW = 370 ± 32 kg) were sorted into 5 weight blocks based on the d -1 BW and randomly assigned to pens (4 pens/block; 9 or 10 steers/pen) using a SAS program (SAS Inst., Inc., Cary, NC) for random assignment of steers within a block to pens based on a procedure to minimize variation in average BW between pens and equalize BW variation within pens. Within block, pens were randomly assigned to 1 of 4 supplemental vitamin E treatments (**VITE**): 0, 125, 250, or 500 IU·steer^{-1}·d^{-1}. The calculated (NRC, 1996) vitamin E concentration of the basal diet was 32.08 IU/kg (DM basis). Duration of vitamin E supplementation was targeted for the last 100 d prior to harvest. However, due to abbatoir scheduling, all pens were subject to their respective VITE treatment feedings the last 97 d prior to harvest. Blocks 1 and 2 were on feed for a total of 129 d. Blocks 3, 4, and 5 were fed for a total of 150 d. Vitamin E supplementation was accomplished by using formulated VITE treatment supplements, which were fine-ground corn with 0.0, 0.0612, 0.1225, or 0.2450% (DM basis) of a 500 mg/g all-*rac*-*α*-tocopheryl acetate premix (Zhejiang NVB Company Ltd., Zhejiang, China; 90% DM basis). These supplements were then top dressed on the common ration at a rate of 204 g·steer^{-1}·feeding^{-1} to meet respective VITE treatment levels. The top dressed supplement was immediately mixed by hand with the ration after delivery in the feedbunk. Steers were individually weighed prior to the morning's feeding the d of VITE supplementation initiation. Final individual live weights were taken prior to the morning's feeding the d the steers were shipped to slaughter. All performance calculations were determined using the average of the trial initiation BW with a 2% pencil shrink and the VIT E supplementation initial BW and final BW with a 4% pencil shrink.

Slaughter and Carcass Evaluation

After final weights were collected, cattle were transported 322 km and slaughtered at a commercial abbatoir. Hot carcass weights were collected at slaughter. Carcasses were chilled for 36 h, ribbed at the 12th rib, and quality and yield grades and carcass traits were recorded. Carcasses were evaluated by trained Oklahoma State University personnel for marbling score, fat thickness at the 12th rib, LM area, percentage of KPH, lean maturity, skeletal maturity, overall maturity, and the incidence of dark cutting beef. Dressing percentage and yield grade were calculated, and quality grade was determined from marbling score and carcass maturity. Loin samples were collected for further retail display and sensory evaluation (Bloomberg et al., 2010).

Statistical Analyses

Feedlot performance and carcass data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC), testing for differences resulting from VITE supplementation level. Pen was the experimental unit, and block was included as a random effect. Utilizing the same model as continuous variables, nonparametric data (carcasses yield and quality grades) were analyzed using the GLIMMIX procedure of SAS on a pen basis as binomial proportions. For all analyses, contrasts were used to test the linear and quadratic responses of increasing level of VITE when the overall F-test probability was $P < 0.10$. Contrasts were discussed as significant if $P < 0.05$ and as a tendency if $P > 0.05$ and < 0.10.

RESULTS AND DISCUSSION

Feedlot performance data collected during the pre-VITE supplementation period, the VITE supplementation period, and over the entire feeding period are presented in Table 3.2. Initial BW, VITE supplementation initial BW, and final BW were not affected by VITE treatments ($P \geq 0.34$). Average daily gains using live weights did not differ between VITE treatments ($P \geq 0.34$). However, ADG calculated using carcass adjusted final weights resulted in a linear increase ($P = 0.04$) in ADG related to a tendency for a linear ($P = 0.08$) increase in carcass adjusted BW due to increasing concentration of supplemental vitamin E. Pre-VITE and VITE period DMI were not affected ($P \geq 0.24$) by VITE treatments, but there was a trend ($P = 0.08$) for a linear increase in overall DMI due to increasing supplemental vitamin E concentration. The 250 IU·steer^{-1}·d^{-1} treatment had the numerically highest DMI in both the pre-VITE supplementation period and the VITE supplementation period. No difference ($P \geq 0.29$) occurred in G:F measures using live weight gains, but G:F using carcass adjusted weight gains resulted in numerical trends for a linear ($P = 0.11$) increase in G:F with increasing concentration of supplemental vitamin E.

Extensive data in the literature has been compiled for receiving and feedlot cattle studying levels of vitamin E supplementation through dietary or systemic routes of administration and with or without selenium. Literature on vitamin E supplementation in DGS diets is limited. Further, results of vitamin E supplementation effects on feedlot cattle are quite variable and inconsistent, with many agreeing with our experiment when using live BW measures in that vitamin E supplementation has little effect on feedlot performance (Meiske et al., 1971; Arnold et al., 1992; Garber et al., 1996). Arnold et al. (1992) conducted three experiments using differing vitamin E supplementation levels and durations in high-moisture corn (**HMC**)-based finishing diets. In experiment one, Holstein steer calves were supplemented with vitamin E at 0 or 500 IU·steer^{-1}·d^{-1} for 9 mo prior to harvest. Experiment two supplemented beef steers at 0 or 2,000 IU·steer^{-1}·d^{-1} for a period of 67 d prior to harvest. Experiment three supplemented Holstein steers at 0 or 2,000 IU·steer^{-1}·d^{-1} during the last 38 d prior to harvest. These researchers reported that vitamin E supplementation within their experimental constraints consistently resulted in no effects on feedlot performance. Garber et al. (1996) investigated supplementing vitamin E to beef and Holstein steers fed a ground corn-based finishing diet which provided each steer with a daily basal vitamin E amount of 167 IU. Steers were also supplemented vitamin E at treatment levels of 0, 250 (beef steers only), 500, 1,000, and 2,000 IU·steer^{-1}·d^{-1}. Cattle were fed treatment diets for a range of 119 to 153 d. From these studies, Garber et al. (1996) concluded that vitamin E supplementation did not affect feedlot cattle performance.

Others have reported improved performance similar to our results calculated with carcass adjusted final weights. In an experiment performed by Secrist et al. (1995), steers were finished on a 92% concentrate HMC-based diet and supplemented with either 100 or 300 IU·steer^{-1}·d^{-1} of vitamin E. Steers were fed treatment diets for 145 d. They reported numerical increases in ADG and DMI, and a tendency for improved feed efficiency with the 300 IU of vitamin E supplementation. Hill et al. (1995) reported yearling steers supplemented for 105 d with 1,500 IU vitamin E·steer^{-1}·d^{-1} compared to 150 IU·steer^{-1}·d^{-1} had improved ADG of 9.8% and feed efficiency of 3.7%. Conversely, in another study in the same report with the same treatment levels but fed for 133 d, there were no effects on cattle performance.

Rivera et al. (2002) supplemented vitamin E at approximately 285, 570, and 1,140 IU·animal^{-1}·d^{-1} to lightweight male calves and heifer calves in 2 separate experiments. They fed the treatment diets for a 28 d receiving period, after which all cattle were subjected to a growing program (196 d for males; 164 d for heifers). Cattle were then finished for 91-98 d on a 90% concentrate steam-flaked corn-based diet that was formulated to provide vitamin E at 133 IU·animal^{-1}·d^{-1}. They observed no difference in BW for either experiment, which agrees with the live BW measured in the present experiment. During the finishing period, they reported the greatest DMI and numerically highest ADG for the steers on the 570 IU·steer^{-1}·d^{-1} treatment. However, in the heifer experiment, they did not find performance or intake differences.

A meta-analysis was performed on the health and performance effects of supplemental vitamin E of feedlot cattle by Cusack et al. (2009). These researchers used a range of receiving and finishing studies varying in vitamin E supplementation level and duration. Due to vitamin E supplementation, they observed 2 of 12 trials to increase ADG, 2 of 11 trials to significantly improve DMI, and 2 of 11 trials to improve G:F. Morbidity was improved by vitamin E supplementation in 1 of 6 trials, and treatment costs were lowered 1 of 2 trials. As a result, Cusack et al. (2009) concluded that vitamin E administration by injection or dietary supplementation above NRC (1996) recommendations does not improve the production variables of ADG, G:F, or morbidity of feedlot cattle.

Secrist et al. (1997) reviewed the effects of vitamin E supplementation in 21 feedlot performance trials. These trials ranged in vitamin E supplementation level from 74 IU·animal^{-1}·d^{-1} to 2,000 IU·animal^{-1}·d^{-1} fed for 38 to 298 d with corn silage, DRC, or HMC-based diets. They observed a 2.9% increase in ADG with no change in DMI that resulted in a 1.8% increase in feed efficiency. They concluded from the review, that the variability of results may be dependent on supplementation level, previous nutritional background, vitamin E status of the calves at the start, stress level of the calves, and vitamin E content of the basal diet (Secrist et al., 1997). In the present experiment, the yearling steers were healthy, previously backgrounded, and hauled less than 1 h from wheat pasture and then limit fed a receiving diet containing adequate levels of vitamin E (NRC, 2000) 38 d prior to the initiation of the experiment.

In the present experiment, hot carcass weight tended (*P* = 0.08; Table 3.3) to increase linearly with increasing concentration of VITE supplementation. VITE supplementation resulted in no significant effects ($P \geq 0.13$) for dressing percentage, LM area, 12th rib fat, or percent KPH. Marbling scores and calculated YG were not affected ($P \geq 0.37$) by VITE supplementation during the last 97 d prior to harvest. This agrees with Liu et al. (1996). They reported no differences in carcass characteristics due to supplementation of vitamin E (levels of 0 to 2,000 IU·animal^{-1}·d^{-1} for 42 or 126 d). However, there are conflicting results on vitamin E supplementation effects on carcass characteristics. The experiment of Rivera et al. (2002) with males resulted in decreased fat thickness and yield grade with greater *longissimus* muscle area for calves fed 570 IU vitamin E·animal^{-1}·d^{-1} treatment. But, in their heifer experiment, they detected no differences in hot carcass weight, marbling, fat thickness, or the percentage of cattle grading USDA choice. These researchers did observe a quadratic response in dressing percent and a linear decrease in *longissimus* muscle area along with a subsequent linear increase in yield grade in heifers supplemented with vitamin E. The experiment conducted by Secrist et al. (1995) showed steers fed 300 IU vitamin E·steer^{-1}·d^{-1} for 145 d prior to harvest had higher marbling scores with a corresponding increase in 12th rib fat compared to steers fed 100 IU vitamin E·steer^{-1}·d^{-1} for the same duration. The review by Secrist et al. (1997) reported that fat thickness, marbling score, and yield grade tended to be numerically increased with vitamin E supplementation. In the present experiment, no differences were observed in the distribution of quality grades based on marbling score ($P \geq 0.57$; Table 3.4). The distribution of calculated YG resulted in a quadratic effect (*P* = 0.02) for YG 3 with the control and 500 IU VITE being higher than the two intermediate levels. However the percentage of carcasses grading YG 3 or lower were not affected by vitamin E supplementation (*P* = 0.64).

IMPLICATIONS

Grain usage for ethanol and subsequent grain milling byproduct production has continued to increase, resulting in substitution of these byproducts for feed grains in cattle finishing diets. Increases in PUFA in DGS-fed beef create a potential increased rate of oxidative rancidity. Feeding increased quantities of vitamin E increases tissue concentration of α-tocopherol and provides protection for membranal unsaturated fatty acid oxidation. The present study demonstrates that vitamin E can be supplemented above NRC (2000) requirements and at levels up to 500 $IU \cdot animal^{-1} \cdot d^{-1}$ for the last 97 d prior to harvest in finishing diets with elevated inclusion levels of WDGS with no adverse effects on feedlot performance or carcass merit.

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Table 3.1. Finishing diet ingredient and nutrient composition.

Item	Concentration
Dry rolled corn, %	55.0
Wet corn distillers grains w/solubles, %	35.0
Ground alfalfa hay, %	7.0
Supplement[1], %	3.0
Nutrient composition, DM basis (except DM)[2]	
Dry matter, %	58.8
Crude protein, %	17.6
ME, mcal/kg	3.02
NEm, mcal/kg	2.29
NEg, mcal/kg	1.39
NDF, %	18.13
Ca, %	0.72
P, %	0.52

[1]Supplement contained (%, DM basis): fine ground corn = 34.31; calcium carbonate = 50.13; salt = 8.33; urea = 3.33; potassium chloride = 1.97; magnesium oxide = 0.01; zinc oxide = 0.23; copper sulfate = 0.12; manganous oxide = 0.21; selenium 600 = 0.18; thiamine 10 = 0.02; vitamin A (30,000 IU/g) = 0.12; Rumensin 80 (Elanco Animal Health, Indianapolis, IN) = 0.63; Tylan 40 (Elanco Animal Health, Indianapolis, IN) = 0.40.

[2]All values except dry matter are calculated based on NRC (2000) values and WDGS analyzed values.

Table 3.2. Effect of supplementing vitamin E to feedlot steers for 97 d before slaughter on feedlot performance.

	Vitamin E Treatment, IU·steer^{-1}·d^{-1}						Significance of Contrast[1]	
Item	Control	125	250	500	SEM[2]	*P*-value	L	Q
No. of Steers	50	50	50	49				
No. of Pens	5	5	5	5				
BW, kg								
Pre-Vit. E[3]	362.8	362.5	363.3	362.3	15	0.93	0.86	0.78
Vit. E[3]	458.2	455.3	464.1	456.7	13	0.49	0.82	0.60
Total[3]	625.4	617.0	630.9	627.8	18	0.34	0.40	0.63
Carcass Adj.[4]	622.4	612.0	635.4	631.1	19	0.06	0.08	0.60
ADG, kg/d								
Pre-Vit. E[3]	2.18	2.14	2.27	2.20	0.15	0.77	0.67	0.86
Vit. E[3]	1.72	1.67	1.72	1.76	0.06	0.37	0.33	0.20
Total[3]	1.86	1.81	1.89	1.88	0.08	0.34	0.35	0.53
Carcass Adj.[4]	1.84	1.77	1.93	1.91	0.08	0.03	0.04	0.45
DMI, kg/d								
Pre-Vit. E[3]	11.44	11.31	11.83	11.37	0.55	0.24	0.70	0.39
Vit. E[3]	10.92	11.01	11.08	11.03	0.48	0.60	0.31	0.42
Total[3]	11.16	11.16	11.51	11.33	0.44	0.10	0.08	0.42
G:F, kg:kg								
Pre-Vit. E[3]	0.191	0.189	0.192	0.192	0.007	0.98	0.79	0.91
Vit. E[3]	0.158	0.152	0.155	0.160	0.004	0.29	0.50	0.09
Total[3]	0.167	0.162	0.165	0.166	0.003	0.55	0.99	0.23
Carcass Adj.[4]	0.165	0.159	0.168	0.168	0.007	0.06	0.11	0.17

[1]Significance of contrasts: L = linear effects of vitamin E supplementation; Q = quadratic effects of vitamin E supplementation.

[2]Standard error of the Least squares means.

[3]Pre-Vit. E = the period prior to vitamin E supplementation; Vit. E = the period of vitamin E supplementation; Total = the period representing total days on feed.

[4]Calculated using carcass adjusted BW as HCW/average dressing percentage of each harvest block.

Table 3.3. Effect of supplementing vitamin E to feedlot steers for 97 d before slaughter on carcass traits.

	Vitamin E Treatment, IU·steer^{-1}·d^{-1}						Significance of Contrast[1]	
Item	Control	125	250	500	SEM[2]	*P*-value	L	Q
No. of Steers	49	49	47	47				
No. of Pens	5	5	5	5				
HCW, kg	400.3	393.6	408.7	405.9	12	0.06	0.08	0.60
Dressing %	64.03	63.77	64.83	64.64	0.43	0.15	0.08	0.92
LM area, cm^2	94.38	93.99	94.32	97.51	2.47	0.61	0.31	0.40
12th-rib fat, cm	1.31	1.31	1.48	1.35	0.06	0.18	0.30	0.31
KPH, %	2.28	2.32	2.26	2.48	0.08	0.13	0.09	0.21
Marbling[3]	439	426	423	442	12	0.62	0.33	0.69
Calculated YG	3.41	3.34	3.48	3.45	0.07	0.37	0.92	0.21

[1]Significance of contrasts: L = linear effects of vitamin E supplementation; Q = quadratic effects of vitamin E supplementation.
[2]Standard error of the Least squares means.
[3]400 = Small00 and 500 = Modest00.

Table 3.4. Effect of supplementing vitamin E to feedlot steers for 97 d before slaughter on quality and yield grade.

	Vitamin E Treatment, IU·steer^{-1}·d^{-1}						Significance of Contrast[1]	
Item	Control	125	250	500	SEM[2]	*P*-value	L	Q
Quality grade[3]								
Ch^{o} to Pr, %	24.49	12.24	12.77	21.28	6.14	0.57	0.81	0.32
Ch^{-}, %	42.86	42.86	53.19	46.81	7.28	0.77	0.62	0.74
Se, %	32.65	44.90	34.04	31.91	7.11	0.66	0.75	0.50
Yield grade								
YG 2, %	6.25	24.49	10.64	6.38	6.14	0.39	0.78	0.28
YG 3, %	81.38	61.28	70.60	83.31	7.88	0.07	0.63	0.02
YG 4, %	12.39	14.14	18.78	6.22	6.26	0.33	0.41	0.15
YG ≤ 3, %	87.68	85.96	81.37	89.72	6.42	0.64	0.89	0.34

[1]Significance of contrasts: L = linear effects of vitamin E supplementation; Q = quadratic effects of vitamin E supplementation.
[2]Standard error of the Least squares means. Largest SEM shown.
[3]Quality grade based on marbling score.

CHAPTER IV

EFFECT OF TWO-RATION BLENDING OR TRADITIONAL STEP-UP PROGRAMS FOR ADAPTATION TO FINISHING DIETS

ABSTRACT: An experiment was conducted to compare feedlot performance and carcass characteristics of heifers adapted over a 28 d period to a 94% concentrate diet using two different adaptation programs. One hundred forty-four heifers (343 ± 41 kg; arrival 1) and one hundred fifty-four heifers (309 ± 35 kg; arrival 2) were blocked by BW and randomly assigned to either a two-ration blending (**2RB**) or traditional step-up (**TRAD**) grain adaptation program. Heifers on the 2RB treatment were fed on a program that decreased the proportion of a 70% concentrate diet in the morning feeding and increased the 94% concentrate diet in the afternoon feeding. Sequential step-up diets fed to TRAD heifers consisted of 70, 76, 82, and 88% concentrate. All heifers received a 94% concentrate finishing diet from d 28 until harvest. Individual BW were measured initially, d 28, at re-implant (d 78 for arrival 1; d 88 for arrival 2), and 1 to 2 d before slaughter. Hot carcass weights were collected at harvest, and carcass data were collected after a 48-h chill. Data were analyzed with pen as the experimental unit, grain adaptation program as the fixed effect, and weight block within arrival as the random effect. There was no difference in DMI for d 0 to 28, d 29 to re-implant, d 29 to final, or d 0 to final ($P \geq 0.54$). There was a tendency ($P = 0.10$) for 2RB heifers to have increased daily within pen DMI variation during the period of d 0 to 6. Heifers on the 2RB program also had increased daily DMI variation ($P = 0.05$) from d 7 to 13. There were no treatment differences in daily DMI variation ($P \geq 0.24$) for all other periods tested. There were also no treatment differences for between pen DMI variation ($P \geq 0.14$). Daily ME intake for the periods of d 0 to 6, d 7 to 13, d 14 to 20, and d 21 to 27 was also not different ($P \geq 0.31$). However, the heifers on the TRAD treatment tended ($P \geq 0.07$) to have a greater daily ME intake from d 21 to 27. Body weight, ADG, and G:F data were not affected by grain adaptation program ($P \geq 0.28$). Percentage of cattle grading USDA Prime, Choice, Select or not graded did not differ ($P \geq 0.14$), nor did percentage USDA Yield Grade 1, 2, 3, or 4 ($P \geq 0.12$). There was an increase in percentage of Choice^{-} carcasses based on marbling score ($P = 0.04$) for the TRAD treatment along with a tendency ($P = 0.09$) for a lower proportion of carcasses not graded. Calculated yield grade did not differ between treatments ($P \geq 0.31$). Data from this experiment suggest that a two-ration blending program can be substituted for a traditional step-up program for adaptation to high-concentrate finishing diets without impacting cattle performance and with little effect on carcass characteristics.

Key words: Adaptation, Carcass merit, Cattle, Feedlot, Finishing diets, Growth

INTRODUCTION

Ruminal adaptation to high-concentrate finishing diets involves microbial population shifts to a greater proportion of amylolytic bacteria and lower proportion of fibrolytic bacteria (Tajima et al., 2000, 2001). The adaptation period in feedlot cattle is widely regarded as a crucial period of time due to potential effects on future health and performance (Brown et al., 2006). Feedlot cattle have traditionally been adapted to high-concentrate finishing diets using sequential step-up diets that increase concentrate levels while decreasing roughage levels over a period of 3 to 4 weeks (Krehbiel et al., 2006). Other methods of adapting cattle to high-concentrate diets include restricted feeding of high-concentrate finishing diets, limited maximum intake of step-up diets, or the sequential step-down of low-starch byproduct feedstuffs such as corn gluten feed and distiller's grains (Krehbiel et al., 2006; Hicks, 2010). In order to successfully adapt cattle to high-concentrate finishing diets while optimizing operational efficiencies in feedlot mills, compromises are made in respect to the number of rations fed during the adaptation period (Milton, 2009). Vasconcelos and Galyean (2007) reported that before the final finisher diet, the average number of step-up diets used by consulting nutritionists was approximately 3.

In the two-ration blending adaptation approach, both a low-concentrate (starter) and high-concentrate (finisher) diet are fed at separate feedings to a pen. The feed delivery ratio of starter:finisher is reduced on a daily basis over a period of 3 to 4 weeks. With the use of two-ration blending, only a starter and a finisher ration are milled and fed. This adaptation method should allow ruminal microorganism populations to gradually adjust to changing substrate and lower ruminal pH, while theoretically improving the operational efficiency of cattle feeding. The objectives of this experiment were to study the effects of adaptation program to a 94% concentrate finishing diet on feedlot performance and carcass characteristics.

MATERIALS AND METHODS

Cattle

An experiment was conducted at the Willard Sparks Beef Research Center to determine effects of adaption method to a 94% concentrate diet on cattle performance and carcass characteristics. For arrival group 1, heifers arrived in May and June of 2009. For arrival group 2, heifers were placed in October of 2009. Heifers were sourced from a buying station in Louisiana and auction markets in Oklahoma.

Upon arrival, heifers were processed and fed ad libitum a 63% concentrate diet for 72 d and 76 d for arrival one and two, respectively. Arrival one heifers were vaccinated against infectious bovine herpes virus-1, bovine viral diarrhea virus (types I and II), bovine parainfluenza-3, and bovine respiratory syncytial virus (Vista 5 SQ, Intervet/Schering-Plough, DeSoto, KS) and clostridial pathogens (Vision 7 with SPUR, Intervet/Schering-Plough), dewormed with ivermectin (Ivomec Plus, Merial, Duluth, GA), and implanted with trenbolone acetate and estradiol (Component TE-G, Vetlife, Overland Park, KS) within 72 h of arrival and re-vaccinated on d 14 (Express 5, Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO). Arrival two heifers were vaccinated against infectious bovine herpes virus-1, bovine viral diarrhea virus (types I and II), bovine parainfluenza-3, bovine respiratory syncytial virus, and *Mannheimia haemolytica* (Pyramid 5 plus Presponse, Intervet/Schering-Plough) and clostridial pathogens (Vision 7 with SPUR, Intervet/Schering-Plough), dewormed internally with fenbendazole

(Panacur, Intervet/Schering-Plough), and poured for external parasites with lambdacyhalothrin with piperonyl butoxide (Ultrasaber, Intervet/Schering Plough). Arrival two heifers were not re-vaccinated.

Experiment

Experiment initial BW (d 0 for arrival one; average d -1 and d 0 for arrival two) was measured after the growing program with a 3% pencil shrink. Heifers (n = 144, 343 ± 41 kg for arrival one; n = 154, 309 ± 35 kg for arrival two) were selected by initial BW. Selected heifers were blocked by BW and assigned to feedlot pens of 6 or 7 heifers per pen using a SAS program (SAS Inst., Cary, NC) for random assignment of heifers within a block to pens based on a procedure to minimize variation in average BW between pens and equalize BW variation within pens. Pens were randomly assigned to either two ration blending (**2RB**) or traditional step-up (**TRAD**) adaptation treatments. Heifers were housed in 4.57 × 15.24 m pens with a 4.57 m fence-line feed bunk. Heifers had ad libitum access to water via an automatic water basin located along the fence line and shared between 2 adjacent pens. Arrival one heifers were implanted on d 28 with trenbolone acetate and estradiol (Revalor-IH, Intervet/Schering Plough) and re-implanted on d 78 with trenbolone acetate and estradiol (Revalor-H, Intervet/Schering Plough). Arrival two heifers were implanted on d 0 with trenbolone acetate and estradiol (Revalor-IH, Intervet/Schering Plough) and re-implanted on d 88 with trenbolone acetate and estradiol (Revalor-200, Intervet/Schering Plough). Arrival 1 heifers were harvested after 145 and 181 d on feed (2 blocks), and arrival 2 heifers were harvested after 182 and 196 d on feed (2 blocks). Body weights were measured on d 28, at re-implant, and 1 or 2 d before slaughter. Performance calculations were based on heifers pencil shrunk 3% at d 28 and

4% at re-implant and final weight events. Heifers were slaughtered at a commercial abattoir. Hot carcass weight was collected at slaughter. Carcasses were chilled for 48 h, ribbed at the 12th rib and USDA Quality and Yield Grades and carcass traits were recorded. Carcasses were evaluated by trained Oklahoma State University personnel for marbling score, fat thickness at the 12th rib, LM area, percentage of KPH, lean maturity, skeletal maturity, overall maturity, and the incidence of dark cutting beef. Dressing percentage and yield grade were calculated, and quality grade was determined from marbling score and carcass maturity.

Feeding Management

Heifers were fed twice daily at 0700 and 1300 h with a mixer wagon (Kuhn/Knight 3125; Kuhn North America, Inc., Brodhead, WI). Diets (Table 4.1) were formulated to meet or exceed NRC requirements. Arrival 1 diets contained melengestrol acetate (MGA 200, Pharmacia and Upjohn, Kalamazoo, MI; 0.033 mg/kg on a 90% DM basis). Arrival 2 heifers were fed zilpaterol hydrochloride (Zilmax, Intervet/Schering Plough, De Soto, KS) for 23 d prior to harvest with a 3 d withdrawal. All experimental diets contained monensin and tylosin (Elanco Animal Health, Greenfield, IN; 33 and 10 mg/kg, respectively, on a 90% DM basis). Dry matter determination (60°C for 48 h) of ration samples was conducted twice a week during the adaptation period and weekly during the finishing period. Feed bunks were cleaned, and orts were weighed before feeding on each weigh day and as needed to ensure feed quality. Samples of orts were dried using the aforementioned method. Dry orts were subtracted from DM delivery for determination of pen DMI. Bunks were read twice daily with the goal of 0 to 1 kg of feed per heifer remaining at morning evaluation, and daily feed call was adjusted before the first feeding. The 2RB heifers were fed first with TRAD heifers fed directly following. All heifers were fed the 70% concentrate diet from d 0 to 7 in arrival 1 and d 0 to 6 ½ in arrival 2. During the adaption period, heifers were fed diets as outlined in Table 4.2. All heifers received the 94% concentrate finishing ration from d 28 until harvest. In arrival 2, feed samples, for determination of ingredient sorting prevalence, were collected from each bunk at 1600 h from d 5 to d 19. These samples were composited by treatment and by day and analyzed at a commercial laboratory (SDK Laboratories, Hutchinson, KS). Mean values and standard deviations for samples within period are reported in Table 4.4 for the periods of d 5 to 6 (period 1; n = 2 samples), d 7 to 13 (period 2; n = 7 samples), d 14 to 19 (period 3; n = 6 samples), and d 5 to 19 (total; n = 15 samples). Variation in DMI during the grain adaptation period and the 1st week of feeding the final finishing diet was performed according to the method outlined by Choat et al. (2002).

Statistical Analysis

Feedlot performance and carcass data were analyzed as a randomized complete block design using the MIXED procedure of SAS (SAS Institute) with adaptation treatment as the fixed effect. Weight block within arrival were included as the random effect. Pen was the experimental unit. Intake variation data were analyzed as repeated measures over time, utilizing the same model as performance and carcass measures with a first-order autoregressive covariance structure. The covariance structure was selected by subjecting the model to multiple covariance structures and the best fit model was selected to contain the covariance structure that yielded the smaller Akaike and Schwarz’s Bayesian criterion based on their – 2 res log-likelihood. Categorical data (calculated quality and yield grades and USDA Quality and Yield Grades) were analyzed using the GLIMMIX procedure of SAS on a pen basis as binomial proportions using the same model as for continuous variables.

RESULTS AND DISCUSSION

Feedlot performance data are summarized in Table 4.3. During the adaptation period, treatment did not affect BW, ADG, DMI, or G:F ($P \geq 0.28$). Subsequent feedlot BW, ADG, DMI, or G:F for the periods of d 29 to re-implant and d 29 to final were also not influenced by adaptation program ($P \geq 0.63$). Overall feedlot ADG, DMI, or G:F was not different between treatments ($P \geq 0.49$). Final BW was also not different between the adaptation programs ($P = 0.62$). Carcass-adjusted final BW and corresponding ADG and G:F were not affected by adaptation program ($P \geq 0.71$). For experimental purposes, feeding programs and diets were designed for equal ME intake assuming equal DMI across the 28 d adaptation period. Average daily ME intake for the periods of d 0 to 6, d 7 to 13, d 14 to 20, d 21 to 27, ($P \geq 0.31$). The heifers on the TRAD treatment tended (P = 0.07) to have greater daily ME intake from d 28 to 34. However, the d 0 to 34 ME intake was not different ($P = 0.94$).

Stock et al. (1995) suggested that when cattle are experiencing acidosis not only is feed intake reduced but also extreme fluctuations in daily feed consumption may also occur. Table 4.5 summarizes the daily within pen DMI variation and between pen DMI variation. There was no treatment × period interaction for either daily or pen DMI variation ($P \geq 0.16$). There was a tendency ($P = 0.10$) for 2RB heifers to have increased daily DMI variation during the period of d 0 to 6. Heifers on the 2RB program also had increased daily DMI variation from d 7 to 13 ($P = 0.05$). There were no treatment differences in daily DMI variation ($P \geq 0.24$) for the periods of d 14 to 20, d 21 to 27, or d 28 to 34. There were also no treatment differences for pen DMI variation ($P \geq 0.14$) for all periods tested. Choat et al. (2002) observed decreased intake variation when comparing restricted feeding of the finishing diet during adaptation to traditional step-up diets.

Analyzed nutrient values of treatment bunk samples are presented in Table 4.4. Collected daily at 1600 h or 3 h after afternoon delivery, these bunk samples represent the prevalence of diet preference and sorting. Due to the differences in feed deliveries across treatments, differences could occur in diet sorting and feed consumption patterns. However, nutrient mean values for period 1, period 2, and the total sampling period are relatively consistent for bunk samples between both adaptation programs. Period 3 nutrient mean values for 2RB bunk samples reflect more closely and therefore suggest that more finisher diet than starter diet was included in the samples collected at 1600 h. This is possibly related to small morning feed calls and slick bunks before finisher diet or afternoon delivery at 1300 h. However in non-experimental commercial situations, this potential problem could be managed by optimization of feeding times.

Adaptation treatment had no affect on HCW, dressing percentage, LMA, 12th rib fat thickness, or KPH ($P \geq 0.22$; Table 4.6). This agrees with Bierman and Pritchard (1996) when comparing prescription feeding of a 92% concentrate diet to a traditional step-up diet program. These researchers reported no effects on carcass characteristics due to adaptation method. Choat et al. (2002) compared restricted access feeding of a finishing diet with traditional ad libitum step-up diets. They reported a decrease in HCW due to a decrease in final live weight in their calf-fed experiment. However, in their yearling steer experiment there were no differences in final live weight or HCW due to treatment effects. These researchers also observed no other effects of adaptation management on carcass characteristics. In the present experiment, marbling score had a tendency ($P = 0.07$) to be increased in heifers adapted with the TRAD adaptation method, agreeing with a numerical increase in fat thickness and calculated yield grade. Based on marbling score, TRAD heifers had an increased percentage of carcasses grading Choice^{-} ($P = 0.04$; Table 4.7), along with a tendency ($P = 0.09$) for a decrease in the percentage of carcasses not graded. There were no treatment differences in the distribution of USDA Quality Grades ($P \geq 0.14$), nor the distribution of USDA YG or calculated YG ($P \geq 0.12$).

Vasconcelos and Galyean (2007) reported that 24 of 29 feedlot consulting nutritionists used traditional step-up diets in their adaptation programs. This type of adaptation program is relatively safe against mixing and feeding mistakes in commercial feedlots, but it also results in small step-up diet load sizes and mixing and feeding a large amount of roughage. In comparison to traditional step-up diet programs, two ration blending programs should reduce total number of loads, increase load size, decrease feeding times, and reduce finished feed storage in feedlot batch mills (Milton, 2009). Although the amount of roughage fed during the adaptation period may or may not be reduced in comparison to step-up diet programs, this method equates to more efficient operational efficiency over traditional step-up diet programs since only 2 rations have to be milled and fed. However, using this method of adaptation does result in small feed calls at the beginning and end of the adaptation period and makes feed distribution and feeding timing very important (Milton, 2009). Two-ration blending also assumes that each calf in a pen will consume a diet that is in the same proportion as the 2 rations fed to the pen. This may be an incorrect assumption (Krehbiel et al., 2006). The increased management and potential problems associated with two-ration blending when utilized at the commercial feedlot level may be the cause of why this practice was only used by 6 of 29 consulting nutritionists (Vasconcelos and Galyean, 2007).

IMPLICATIONS

This experiment substantiates that two ration blending adaptation programs can be used in small pen situations with no adverse effects on performance or carcass characteristics. Due to elimination of required adaptation rations, feedlot operational efficiency should theoretically be improved. However, two ration blending may require increased daily management of feed calls, feed timing, and feed distribution over traditional step-up approaches.

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Table 4.1. Diet ingredient and nutrient composition.

	Diet[1]				
	70	76	82	88	94
Dry rolled corn	42.0	49.0	56.0	63.0	70.0
Corn DDGS	18.0	16.5	15.0	13.5	12.0
Ground alfalfa hay	12.0	9.0	6.0	3.0	-
Ground prairie hay	18.0	15.0	12.0	9.0	6.0
Liquid supplement[2]	4.0	4.5	5.0	5.5	6.0
Pellet supplement[3]	6.0	6.0	6.0	6.0	6.0
Nutrient composition[4]					
Dry matter, %	79.71	80.04	78.82	79.67	78.65
Crude protein, %	15.83	14.81	14.31	14.29	13.01
ME, mcal/kg	2.73	2.73	2.78	2.87	2.93
NEm, mcal/kg	1.90	1.90	1.94	2.03	2.07
NEg, mcal/kg	1.19	1.19	1.21	1.30	1.34
Fat, %	5.78	5.52	5.96	6.38	6.10
NDF, %	24.97	22.38	22.64	16.68	13.88
ADF, %	14.87	14.19	13.17	8.79	6.65
Ca, %	0.85	0.67	0.55	0.54	0.48
P, %	0.38	0.32	0.38	0.41	0.33

[1]Diet percent concentrate.

[2]Synergy 19/14 (Westway Feed Products, New Orleans, LA).

[3]Pelleted supplement contained the following (DM basis): 45.49% to 45.78% ground corn, 16.67% wheat middlings, 25.83% limestone, 4.00% salt, 3.33% urea, 1.83% potassium chloride, 1.67% magnesium oxide, 0.05% manganous oxide, 0.25% zinc sulfate, 0.05% vitamin A (30,000 IU/g), 0.04% vitamin E (50%), 0.31% Rumensin 80 (Elanco Animal Health, Indianapolis, IN), and 0.19% Tylan 40 (Elanco Animal Health), 0.13% MGA 200 (Pharmacia & Upjohn Company, Kalamazoo, MI) in experiment 1, and 0.29% Zilmax (Intervet/Schering Plough, De Soto, KS) for experiment 2 during the last 23 days prior to harvest with a 3 day withdrawal.

[4]All values except dry matter are analyzed values expressed on a DM basis.

Table 4.2. Adaptation period feed call protocol for adapting heifers to a 94% concentrate finishing diet using traditional step-up or two-ration blending approaches (DM basis).

	Traditional Step-up				Two-Ration Blending			
	Morning feeding		Afternoon feeding		Morning feeding		Afternoon feeding	
Day	% of Call[1]	Diet[2]	% of Call[1]	Diet[2]	% of Call[1]	Diet[2]	% of Call[1]	Diet[2]
0-5	50.00	70	50.00	70	50.00	70	50.00	70
6	50.00	70	50.00	70 (76)[3]	50.00	70	50.00	70
7	50.00	76 (70)[3]	50.00	76	95.45	70	4.55	94
8	50.00	76	50.00	76	90.91	70	9.09	94
9	50.00	76	50.00	76	86.36	70	13.64	94
10	50.00	76	50.00	76	81.82	70	18.18	94
11	50.00	76	50.00	76	77.27	70	22.73	94
12	50.00	76	50.00	76	72.73	70	27.27	94
13	50.00	76	50.00	76 (82)[3]	68.18	70	31.82	94
14	50.00	82 (76)[3]	50.00	82	63.64	70	36.36	94
15	50.00	82	50.00	82	59.09	70	40.91	94
16	50.00	82	50.00	82	54.55	70	45.45	94
17	50.00	82	50.00	82	50.00	70	50.00	94
18	50.00	82	50.00	82	45.45	70	54.55	94
19	50.00	82	50.00	82	40.91	70	59.09	94
20	50.00	82	50.00	82 (88)[3]	36.36	70	63.64	94
21	50.00	88 (82)[3]	50.00	88	31.82	70	68.18	94
22	50.00	88	50.00	88	27.27	70	72.73	94
23	50.00	88	50.00	88	22.73	70	77.27	94
24	50.00	88	50.00	88	18.18	70	81.82	94
25	50.00	88	50.00	88	13.64	70	86.36	94
26	50.00	88	50.00	88	9.09	70	90.91	94
27	50.00	88	50.00	88	4.55	70	95.45	94
28-end	50.00	94	50.00	94	50.00	94	50.00	94

[1]Percent of daily feed call.

[2]Diet percent concentrate.
[3]Diet percent concentrate modifications made in experiment 2.

Table 4.3. Effect of finishing diet adaptation program on feedlot performance.

Item	Adaptation Program[1] TRAD	2RB	SEM[2]	*P*-value
No. of heifers	145	146		
No. of pens	24	24		
BW, kg				
d 0	321.8	321.0	21.7	0.57
d 28	358.9	357.1	17.1	0.28
Reimplant[3]	411.5	410.2	21.6	0.63
Final	502.0	499.7	10.3	0.62
Carcass Adj.[4]	501.6	499.7	10.7	0.74
ADG, kg/d				
d 0 to 28	1.33	1.28	0.17	0.36
d 29 to reimplant[3]	0.97	0.98	0.17	0.86
d 29 to final	0.98	0.97	0.07	0.71
d 0 to final	1.03	1.02	0.09	0.57
Carcass Adj.[4]	1.03	1.02	0.08	0.76
DMI, kg/d				
d 0 to 28	8.29	8.36	0.33	0.54
d 29 to reimplant[3]	7.70	7.67	0.21	0.84
d 29 to final	7.51	7.52	0.18	0.95
d 0 to final	7.64	7.65	0.19	0.91
G:F, kg:kg				
d 0 to 28	0.161	0.156	0.025	0.35
d 29 to reimplant[3]	0.127	0.128	0.020	0.76
d 29 to final	0.131	0.129	0.013	0.67
d 0 to final	0.136	0.134	0.014	0.49
Carcass Adj.[4]	0.135	0.134	0.014	0.71
ME Intake, Mcal/d				
d 0 to 6	22.9	23.0	1.1	0.89
d 7 to 13	22.9	23.1	1.1	0.50
d 14 to 20	23.2	23.6	0.8	0.31
d 21 to 27	23.4	23.6	0.9	0.72
d 28 to 34	21.5	20.7	0.7	0.07
d 0 to 34	22.8	22.8	0.9	0.94

[1]Adaptation program: traditional step-up (TRAD), two-ration blending (2RB).

[2]Standard error of the Least squares means. Largest SEM shown.

[3]Re-implant = d 78 for experiment 1; d 88 for experiment 2.

[4]Calculated using carcass adjusted BW as HCW/average dressing percentage of each harvest block.

Table 4.4. Effect of finishing diet adaptation method on daily bunk sample nutrient composition (arrival 2).[1]

	TRAD[2]		2RB[2]	
Item	Mean	SD[3]	Mean	SD[3]
Period 1[4]				
Dry matter, %	78.6	0.2	78.6	0.4
Crude protein, %	14.6	0.7	14.4	0.6
ME, mcal/kg	2.63	0.11	2.63	0.02
NEm, mcal/kg	1.82	0.08	1.82	0.02
NEg, mcal/kg	1.10	0.09	1.10	0.03
Fat, %	5.48	0.50	5.54	0.34
NDF, %	29.8	2.7	28.0	0.3
ADF, %	18.7	3.8	18.7	0.7
Period 2[4]				
Dry matter, %	77.7	2.7	74.7	4.0
Crude protein, %	14.4	0.6	14.3	0.9
ME, mcal/kg	2.78	0.06	2.79	0.07
NEm, mcal/kg	1.94	0.05	1.95	0.06
NEg, mcal/kg	1.22	0.05	1.23	0.06
Fat, %	6.55	0.50	6.48	0.76
NDF, %	23.3	2.0	22.6	3.3
ADF, %	13.9	2.1	13.1	2.6
Period 3[4]				
Dry matter, %	78.3	0.3	77.4	0.9
Crude protein, %	13.6	0.1	12.8	0.6
ME, mcal/kg	2.80	0.03	2.86	0.07
NEm, mcal/kg	1.95	0.02	2.00	0.06
NEg, mcal/kg	1.24	0.02	1.29	0.05
Fat, %	5.32	0.46	5.53	0.71
NDF, %	19.7	0.9	16.3	4.5
ADF, %	11.0	1.0	8.4	3.4
TOTAL[4]				
Dry matter, %	78.1	1.8	76.3	3.1
Crude protein, %	14.1	0.6	13.7	1.0
ME, mcal/kg	2.77	0.08	2.80	0.10
NEm, mcal/kg	1.93	0.06	1.96	0.08
NEg, mcal/kg	1.21	0.06	1.24	0.08
Fat, %	5.91	0.76	5.98	0.82
NDF, %	22.7	3.7	20.8	5.5
ADF, %	13.4	3.2	12.0	4.4

[1]Analyzed values (SDK Laboratories, Hucthinson, KS).
[2]Adaptation program: traditional step-up (TRAD), two-ration blending (2RB).
[3]SD = standard deviation.
[4]Period 1 = d 5 to 6, Period 2 = d 7 to 13, and Period 3 = d 14 to 19.

Table 4.5. Effect of finishing diet adaptation method on dry matter intake variation.

Item	Adaptation Program[1] TRAD	2RB	SEM[2]	*P*-value
Daily DMI variation[3], kg^2				
d 0 to 6	1.22	1.58	0.15	0.10
d 7 to 13	1.20	1.63	0.15	0.05
d 14 to 20	0.77	1.02	0.15	0.24
d 21 to 27	0.99	1.08	0.15	0.66
d 28 to 34	1.03	0.78	0.15	0.24
Pen DMI Variation[4], kg^2				
d 0 to 6	0.33	0.22	0.10	0.14
d 7 to 13	0.12	0.17	0.10	0.54
d 14 to 20	0.17	0.14	0.10	0.72
d 21 to 27	0.33	0.37	0.10	0.58
d 28 to 34	0.22	0.20	0.10	0.78

[1]Adaptation program: traditional step-up (TRAD), two-ration blending (2RB).
[2]Standard error of the Least squares means. Largest SEM shown.
[3]Within pen daily DMI variation; Treatment × period interaction ($P = 0.16$).
[4]Between pen DMI variation; Treatment × period interaction ($P = 0.55$).

Table 4.6. Effect of finishing diet adaptation program on carcass traits.

	Adaptation Program[1]			
Item	TRAD	2RB	SEM[2]	*P*-value
No. of heifers	136	135		
No. of pens	24	24		
HCW, kg	321.8	320.5	10.5	0.73
Dressing %	64.1	64.2	1.3	0.74
LM area, cm^2	82.3	83.2	9.6	0.44
12th-rib fat, cm	1.50	1.42	0.18	0.22
KPH, %	2.51	2.43	0.58	0.42
Marbling[3]	402.8	386.9	34.6	0.07
Calculated YG	3.17	3.05	0.78	0.33

[1]Adaptation program: traditional step-up (TRAD), two-ration blending (2RB).
[2]Standard error of the Least squares means. Largest SEM shown.
[3]Marbling score units: 300 = Slight00, 400 = Small00, 500 = Modest00

Table 4.7. Effect of finishing diet adaptation program on distribution of USDA Quality and Yield Grades and calculated quality and yield grades.

	Adaptation Program[1]			
Item	TRAD	2RB	SEM[2]	*P*-value
USDA Quality Grade[3]				
Prime	2.01	1.98	0.01	0.98
Choice	67.92	60.66	0.12	0.22
Select	28.54	32.91	0.12	0.44
No roll	0.67	3.34	0.02	0.14
Quality grade[4]				
$Choice^+$	0.56	0.96	0.02	0.57
$Choice^o$	6.90	6.55	0.06	0.90
$Choice^-$	45.15	32.08	0.09	0.04
Select	39.23	46.28	0.08	0.25
No roll	0.65	1.71	0.05	0.09
USDA Yield Grade[3]				
1.00	14.33	20.29	0.09	0.19
2.00	36.87	37.53	0.09	0.91
3.00	35.93	32.75	0.10	0.58
4.00	7.44	3.69	0.07	0.12
Calculated yield grade				
1.00	12.16	14.82	0.15	0.50
2.00 to 2.49	16.01	15.36	0.10	0.88
2.50 to 2.99	15.27	16.14	0.07	0.84
3.00 to 3.49	12.88	10.25	0.05	0.50
3.50 to 3.99	12.13	9.62	0.06	0.50
4.00 to 4.49	3.55	5.44	0.09	0.31
4.50 to 4.49	1.58	0.88	0.05	0.32
5.00	1.05	1.35	0.04	0.63

[1]Adaptation program: traditional step-up (TRAD), two-ration blending (2RB).
[2]Standard error of the Least squares means. Largest SEM shown.
[3]Data collected from USDA grader at commercial abbatoir called at chain speed.
[4]Quality grade based on marbling score.

APPPENDIX

All procedures involving live animals were approved by the

Oklahoma State University Institutional Animal Care and Use Committee.

VITA

Dirk Benedict Burken

Candidate for the Degree of

Master of Science

Thesis: EVALUATION OF DIET ADAPTATION PROGRAMS AND SUPRANUTRITIONAL DIETARY ANTIOXIDANTS FOR FEEDLOT CATTLE

Major Field: Animal Science

Biographical:

Education:

Completed the requirements for the Master of Science in Animal Science at Oklahoma State University, Stillwater, Oklahoma in December, 2010.

Completed the requirements for the Bachelor of Science in Animal Science at the University of Nebraska-Lincoln, Lincoln, Nebraska in December, 2008.

Experience: Employed as a summer laborer by Witte Farms, Blue Hill, NE, 2002-2006; Summer yard employee at Lewis Feedlot, Kearney, NE 2007; Summer feedlot intern at Oppliger Feeders LLC., Wallace, NE, 2008; research coordinator for Willard Sparks Beef Research Center 2009-present, Department of Animal Science, Oklahoma State University.

Professional Memberships: American Society of Animal Science

Name: Dirk Benedict Burken Date of Degree: December, 2010

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: EVALUATION OF DIET ADAPTATION PROGRAMS AND SUPRANUTRITIONAL DIETARY ANTIOXIDANTS FOR FEEDLOT CATTLE

Pages in Study: 77 Candidate for the Degree of Master of Science

Major Field: Animal Science

To evaluate feedlot performance and carcass characteristics of finishing beef steers fed diets containing wet distiller's grains with solubles (WDGS) and supplemented with vitamin E, one hundred ninety-nine steers (370 ± 32 kg) were blocked by BW and randomly assigned to 1 of 4 supplemental vitamin E (VITE) treatment levels (0, 125, 250, and 500 IU·steer^{-1}·day^{-1}) fed for the last 97 d of the feeding period. BW and ADG were not affected by VITE treatments. Carcass adjusted final weights resulted in a linear increase in ADG related to a tendency for a linear increase in carcass adjusted BW with increasing concentration of vitamin E supplementation. Pre-VITE and VITE period DMI were not affected by VITE treatments, but there was a trend for a linear increase in overall DMI with increased dietary vitamin E. No difference occurred in G:F measures using live weight gains, but G:F using carcass adjusted weight gains resulted in a trend for a linear increase with increasing dietary vitamin E. Hot carcass weight tended to increase linearly with increasing concentration of vitamin E. Vitamin E supplementation did not affect measured carcass characteristics. A second experiment compared feedlot performance, carcass characteristics, and intake variation of heifers adapted over 28 d to a 94% concentrate diet with 2 different adaptation programs. One hundred forty-four heifers (343 ± 41 kg; arrival 1) and 154 heifers (309 ± 35 kg; arrival 2) were blocked by BW and randomly assigned to either a two-ration blending (2RB) or traditional step-up (TRAD) grain adaptation program. There was no difference in DMI for any period tested. There was a tendency for 2RB heifers to have increased daily DMI variation during the period of d 0 to 6. Heifers on the 2RB program also had increased DMI variation from d 7 to 13. There were no treatment differences in daily DMI variation for all other periods tested. There were also no treatment differences for pen DMI variation. Daily ME intake for the periods of d 0 to 7, d 8 to 14, d 15 to 21, and d 22 to 28 were not different. The heifers on the TRAD treatment tended to have a greater daily ME intake from d 22 to 28. Daily ME intake for d 0 to 35 was not different. Body weight, ADG, and G:F data were not affected by grain adaptation program. Percentage of cattle grading USDA Prime, Choice, Select, or not graded did not differ, nor did percentage USDA Yield Grade 1, 2, 3, or 4. There was an increase in percentage of Choice^{-} carcasses based on marbling score for the TRAD treatment along with a tendency for a lower proportion of carcasses not graded. Calculated yield grade did not differ between treatments.

ADVISER'S APPROVAL: Dr. Chris J. Richards