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USE OF DISTILLER GRAINS IN ALTERNATIVE BEEF HEIFER SYSTEMS

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by

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Every year, producers select replacement heifers with the intention that these heifers are the future of their cow herd. Producers normally select replacement heifers at weaning based on weight and structure. When selecting heifers at weaning, producers risk not selecting heifers that would be productive cows based on their criteria. By delaying the selection of replacements, it will allow producers to increase the opportunity to thoroughly evaluate replacement prospects. The corn dry-milling industry produces byproducts that can be economical supplements to growing cattle on forage. An experiment evaluated an alternative heifer system utilizing distiller grains as an energy source to heifers. A distiller grain supplement was fed ad-libitum to heifers on pasture to maximize gain. Heifers consuming the distiller grain supplement were able to increase their BW while increasing the stocking rate in the pasture. Supplemented heifers were able to reach their targeted harvest point before nonsupplemented heifers. This alternative production system could provide a viable option for marketing heifers in a yearling or cow/calf enterprise.

Key Words: distiller grains, heifers, alternative system

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CHAPTER 1

A Review of the Literature

I. Distiller Grains

Ethanol Process

Within the United States, Nebraska ranks third in corn grain production (Nebraska Department of Agriculture, 2013). In Nebraska, 24 ethanol plants utilize over 40% of the corn crop, ranking Nebraska second in ethanol production (Nebraska Ethanol Board, 2013). A byproduct from ethanol production is distiller grains which are a relatively available, high quality feed source that can be fed to cattle.

There are two milling methods that can take place during the ethanol process. One is the dry milling process which produces distiller grains plus solubles, while the other method produces corn gluten feed through the wet milling process. In the dry milling process, the corn is ground and the starch is fermented into ethanol and CO_2. After the starch is fermented, about two thirds of the corn kernel (DM) goes into the production of ethanol while the remaining one third remains as a feed product (Klopfenstein et al., 2008). This results in a byproduct that is concentrated three-fold due to the corn kernels composition of approximately two-thirds starch. After the distillation step, the resulting product, stillage, is centrifuged to separate the distiller grains from the distiller solubles. The solubles can either be added back to the distiller grains or be used as a liquid feed supplement. The dry milling process can produce the following byproducts: dried distiller grains plus solubles (DDGS), wet distillers grains plus solubles (WDGS), condensed corn distiller solubles (CCDS), and modified wet distiller grains plus solubles (MWDGS; Erickson et al., 2010). These by-products are high in fermentable fiber (40-45%), fat

(12%), protein (30% CP) that is 15 to 20% undegraded intake protein (UIP; DM basis), and low in starch (Lodge et al. 1997; MacDonald et al., 2007).

The wet milling process requires higher quality #2 corn because several of the products are intended for human consumption. Products from the wet milling process that are intended for human consumption are corn syrup, corn oil, and sweeteners. The corn kernels are steeped and separated into kernel components of corn bran, starch, corn gluten meal, germ, and soluble components. The steep is then added to the fermentation vats where the ethanol is distilled off. The solution that is distilled off is known as distiller solubles and is later added to a portion of the steep liquor and bran fraction resulting in wet corn gluten feed. The two byproducts of the wet milling process are wet corn gluten feed (WCGF) and steep. Wet corn gluten feed contains more energy (136% the feeding value of corn) and protein than corn bran or germ meal alone, but can vary depending on plant, due to the amount of steep each plant adds (Scott et al., 1997).

Composition

Due to the differences in the production processes of corn milling, byproducts can vary in nutrient composition depending on location. They can also vary between different batches made at the same plant. At six dry milling plants, samples (n = 1200) of wet distiller grains and modified distiller grains were collected for five days, across four months, and were analyzed for DM, CP, fat, P, and sulfur (Buckner et al., 2008). There was a numeric difference between DM within each plant however they were not statistically different. There was minimal variation between plants for CP and P, but fat content varied from 10.9 to 13.0% due to the amount of distiller solubles that were added back into the grain. However, S content varied the largest between the plants ranging from 3-13% (Buckner et al., 2008). This shows that distiller grains should be tested and monitored regularly to ensure nutrient values that are being used for distiller grains are correct.

According to the National Research Council (NRC; 2000), the nutrient composition for dried distiller grains plus solubles is 91% DM, 88% TDN, 29.5% CP, 10.3% fat, 0.83% P, and 0.4% S. This nutrient composition suggests that corn milling byproducts are an excellent feed supplement that is high in CP, TDN, and P. Stock et al. (1995) reported TDN values as high as 108% TDN concluding that distiller grains are an excellent source of energy in a ration. Distiller grains are also a good source of undegradable intake protein (UIP). Studies have reported values of 55% of CP as UIP, but in most cases, UIP values range from 47 to 63% UIP (Schroeder, 2012). Due to most of the proteins being degraded by heat during the fermentation process, the protein content that remains in the distiller grain is going to be proportionally higher in UIP, compared to the protein content of the original grain. However, if the UIP is extremely high or above 80%, protein may have become heat damaged and protein may be completely indigestible.

Use in Forage Situations

When grains contain large amounts of starch, there is a negative associative effect between starch and forage digestibility which leads to overall depression of forage utilization (Larson et al., 2011). The depression of forage utilization is due to the competition between amolytic and cellulolytic microbes. Due to starch being removed in the ethanol process, byproducts are an ideal supplement for cattle while grazing forages.

The supplementation of distiller grains may be beneficial during the dormant grazing season or when forage quality and quantity is low. Distiller grains are an excellent source of protein and energy. If distiller grains are included as a supplement in the diet at less than 15%, the distiller grains are considered a protein supplement, but if they are supplemented at more than 15% of the diet, they would be considered both a protein and energy supplement (Stalker et al., 2010).

Producers with long yearling, heifer development, or backgrounding systems, may find it beneficial to supplement when feeding low quality forage. During this time period, calves are still growing which usually results in a nutrient deficiency or decrease in performance. When developing heifers, dormant or low quality forage may not be able to meet the metabolizable protein (MP) requirements of the heifers. By supplementing distiller grains with dormant or low quality forage, heifers meet or exceed the MP requirements due to CP in distiller grains being approximately 50% or more in the form of undegradable intake protein (UIP); (Martin et al., 2007).

When distiller grains were supplemented during the growing season, cattle were able to increase their performance in a quadratic manner (Buttrey et al., 2012). Cattle were able to maximize gain when supplemented at greater than 1.2% BW (Griffin et al., 2007). Supplementing at more than 1.2% BW led to increases in ADG that were due to the availability of both ME and CP (Griffin et al., 2007).

Wet distiller grains with solubles were supplemented to spayed heifers to determine the optimal winter and summer supplementation of distiller grains within a forage based system. Heifers were fed 0.91 kg or 2.27 kg (DM basis) of WDGS on corn residue and fed 0% or 0.6% of BW DM basis MDGS while grazing during the summer

(Gillespie et al., 2014c). When feeding 2.27 kg of distiller grains, winter ADG was higher than heifers receiving 0.91 kg. Heifers receiving greater amounts of distiller grains produced 19.05 kg heavier carcasses at finishing. Summer supplementation increased heifer ADG, but also increased G:F during the finishing phase and HCW was only increased by 2.72 kg.

An economic analysis was completed of supplementing distiller grains to grazing yearling steers on smooth bromegrass pastures. Over a seven year period, cattle that were supplemented distiller grains had greater net returns, lower cost of gain, and lower break even prices than calves that were not supplemented distiller grains (Moore et al., 2013). This was also true in four economic scenarios of different corn and distiller prices. Cattle that were supplemented at the high level, returned more profit than cattle fed at the low levels of supplementation during the background phase (Gillespie et al., 2014b).

Replacement of Forage

Distiller gains have been used as a forage replacement tool. Even though distiller grains are used to replace forage, they traditionally result in an increase in animal performance. MacDonald et al., (2007) defined the forage replacement rate as the unit reduction in forage intake per unit of supplementation consumed by the animal. Watson et al., (2012) reported that when steers are grazing vegetative smooth brome grass, a steer replaced 0.79 kg of forage for every kilogram of DDGS consumed. In 2007, MacDonald et al., also measured forage replacement and reported a slightly lower value of 0.50 kg of forage being replaced with each kilogram of DDGS supplementation.

Horn et al., (1995) and Bumpus (2006) found that providing supplemental energy to cattle results in decreased forage DMI due to the supplement replacing a part of the forage that is consumed. By increasing stocking density in supplemented pastures over non-supplemented pastures, there was no difference between the two pastures in forage mass on several clipping dates. This result shows that there was substitution effect between the intake of the supplemental energy and the intake of forage.

MacDonald et al., (2007) reported that stocking rates could be increased by 10 to 20% of cattle, normally consuming 2.0% of BW daily in forage, were supplemented daily from 0.5 to 0.75% BW. This estimate is based on DDG replacing grazed forage at about 50% of the amount supplemented for cattle receiving up to 7.5 g of DDG per kilogram of BW. The increased stocking rate is due to the DDG replacing grazed forage allowing for more forage available to be grazed.

Across a two year study, heifers were supplemented MDGS to determine the forage savings by feeding a supplement. Heifers on the supplement have a 0.63 kg greater ADG and consumed about 17% less forage than heifers that were not being supplemented (Gillespie et al., 2014c). Supplementing MDGS, while grazing forage, increases summer grains while decreasing the amount of forage that is consumed.

A summary analysis was conducted of yearlings grazing summer pasture while being supplemented distiller grains. The mean substitution rate was 0.23 kg of forage per kg of DG supplemented (Klopfenstein et al., 2007). The study concluded that calves grazed at a moderate stocking rate can expect to see a reduction in grazed forage intake when distiller grains were supplemented to the calves. The calves fed harvested forages and supplemented distiller grains gained 0.08 kg/day per each kg of distiller grains. Yearlings gained less than calves at 0.06 kg/day in response to supplementation of 0.45 kg of distiller grains.

Storage Methods

The effectiveness of distiller grains in a grazing situation depends greatly on how they are stored and the method in which they are fed. Since distiller grains can vary in how they are fed, the DM content and their granular size helps dictate the feeding loss between each type of distiller grains.

When comparing the flowability and handling characteristics of distiller grains, their physical properties play a significant role in how they are going to be handled and stored. Distiller grains flow is often problematic due to restrictions from caking and bridging when it is being stored. This issue is usually a result of temperature variations, storage moisture, relative humidity, particle size, and length of time in storage. In an investigation of the flow behavior of distiller grains at different moisture levels, it was concluded that an increase in moisture content resulted in an increase in cohesiveness and compressibility to the product (Ganesan et al., 2008).

The handling and storage of wet distiller grains can become a challenge due to the limited shelf-life of this product and the quantity received at one time. Depending on the weather conditions and time of year, wet distiller grains can only last up to 30 days post-delivery and even less during the summer months. Studies suggest that by storing wet distiller grains in a bunker and covered with 6-mil black plastic and tires, WDGS can last up to 200 days and have similar nutrient composition as the same day it was delivered. Shrink was estimated at 10% over the 200 days and there was no fermentation due to the wet distiller grains acidic nature (Garcia et al., 2008). Wet distiller grains can also be stored in silo bags mixed with forages at different forage amounts depending on the DM of the forage (Adams et al., 2007). The forage is added so the wet distiller grains can be packed or stored in a silo to help reduce the exposure to oxygen to prevent spoilage.

By drying distiller grains, it increases its shelf-life and allows it to be transported over farther distances. Dry distiller grains are best stored in an area that is protected from wind and rain; normally in an overhead bin or on a flat surface. For long term storage, make sure that the moisture content is below 15% to help prevent spoilage or bridging problems (Lardy, 2007). Handling of the dry product usually results in a shrink or loss between 2-5% (Schoeder, 2012).

Condensed distillers solubles are often stored in bulk tanks prior to being fed. Lardy (2007) reported that bulk tanks should be buried underground or stored indoors to help prevent the solubles from becoming frozen. Condensed corn distiller solubles should be agitated at least 45 minutes before being fed due to the product components becoming separated over time.

Feeding Methods

Several studies have researched different types of distiller grains being fed in bunks or on the ground. Dry distiller grains were fed to steers either in a bunk or on the ground while the steers were grazing subirrigated meadows. In the areas that the supplement was fed, grass was slightly greener compared to areas where distiller grains were not fed. This is due to the phosphorus that is found in the distiller grains. Steers that were fed in the bunk (0.87 kg) had a greater ADG than the steers that were fed the distiller grains on the ground (0.42 kg; Musgrave et al., 2012). Intake was calculated using the NRC to determine the distiller grain waste by back calculating based on ADG. Steers that were fed in a bunk had a waste between 36-41%, but if steers were fed wet distiller grains with solubles on the ground, they had a 13% greater waste than steers fed dry distiller grains in a bunk (Musgrave et al., 2010). In another study, cows were supplemented wet distiller grains with solubles on upland Sandhills winter range in a bunk or on the ground. Cows that were fed in the bunk, gained body condition score (BCS) and gained body weight while the cows that were fed on the ground did not (Musgrave et al., 2010).

When comparing the economics of feeding distiller grains in a bunk to on the ground, the most profitable feeding method depends on the production goal. If least cost is the production goal, then feeding the distiller grains on the ground is more cost effective (Gillespie et al., 2014a). If the goal is to maximize profitability, then feeding in a bunk would be the most profitable feeding method. In these studies, the bunk cost was figured in at $0.16 per day to help decrease distiller grain waste. If distiller grains were priced at $200 (DM) per ton, steers fed on the subirrigated meadow in a bunk would waste between $0.08 and $0.09 per day (Musgrave et al., 2012). When bunk feeding is more desirable, the cost of gain for steers that are fed distiller grains in bunk was less than steers' breakeven price exhibiting that it was more profitable to feed the steers in bunks (Musgrave et al., 2012).

Supply and Demand

In 2013, the USDA projected that 32.5 million tons of distiller grains would be produced. This is a 66% increase from eight years ago. With the increase in demand of distiller grains as a feed source, there is also an increase in the price of distiller grains. Historically, the distiller grains market has been a very volatile market. In 2000 to 2002, distiller grains were priced at 115 to 120 percent the price of corn. However in 2009, the distiller grains were priced at around 90 to 94 percent the price of corn and today distiller grains are priced closer to 110 to 112 percent the price of corn (USDA, 2014). The volatility of the market all depends on the supply and demand of corn and its byproducts.

Distiller grain prices are also very volatile throughout the year. This volatility directly reflects the supply and demand of distiller grains throughout the year. In 2013, distiller grains were priced the highest during the fall months due to the demand of distiller grains being high. Conversely, the lowest price for distiller grains was during the summer months. In 2013, the prices of distillers compared to the price of corn ranged from 140 percent in the December to 89 percent in June (USDA, 2014). This shows that as supply increases the prices of distiller grains decreases, but consequently as the supply decreases the price increases.

Pricing

An analysis was performed to compare WDGS, MDGS, and DDGS to determine byproduct returns when fed to cattle. Spring 2010 prices were used throughout this analysis. Corn was priced at $3.30/bu, WDGS at $34 per ton as is (32% DM), MDGS at $46 per ton as is (48% DM), and DDGS at $100 per ton as is (90% DM; Buckner et al., 2011). Transportation was accounted at $3.50 loaded mile and was transported 50 miles. When comparing the feedstuffs based on dollars per ton of DM, DDGS produced the greatest returns followed by MDGS, WDGS, and finally corn (Buckner et al., 2011).

A study was performed to evaluate the cost of drying distiller grains from the WDGS form if producers had to purchase distiller grain products based on the drying cost (Buckner et al., 2011). On a 100% dry matter basis, WDGS were priced at $106.25 per ton, DDGS were priced at $139.58 per ton, and MDGS were priced at $114.01 per ton.

Due to drying, the most economical byproduct was WDGS, followed by MDGS, and then DDGS. This scenario demonstrates how important it is to compare byproducts equally to each other; either comparing byproducts on a nutrient basis or DM basis.

II. Calf Management Systems

Calf-feds

The cattle population is very diverse when it comes to frame size and BW (Dolezal et al., 1993). If a calf with a large frame is placed into a forage based system at weaning, they will often become overweight and will be discounted at harvest (Vieselmeyer, 1993). Calf-fed systems or intensive systems place heavy BW and large framed calves directly into the feedlot for finishing (Griffin et al., 2007). Placing calves in intensive feeding systems will result in a higher feed efficiency but will sell less weight at harvest and require more days on feed that yearling systems (Feuz, 2002; Shain et al., 2005; Tatum et al., 2006).

A comparison was performed between the production of the calf-fed system to the yearling system. When calf-feds were received, they were 52 kg heavier than the steers entering the long-yearling system, but when comparing the calf-fed and long-yearling BW at feedlot entry, long-yearling steers were 144 kg heavier due to the long-yearlings being grown before entering feedlot. In the feedlot, long-yearlings had a greater ADG (0.33 kg greater); however calf-feds were 18.7% more efficient than long-yearlings (Griffin et al., 2007). Adams et al. (2007) supported this by reporting that the calf-fed steers had the lowest ADG (1.62 kg/d) between calf-feds and long-yearling systems.

Comparing carcass data, long-yearlings fattened at a faster rate due to achieving most of their muscle growth and develop during the time they were being backgrounded.

Calf-feds had a lighter hot carcass weight (24 kg lighter) than long-yearlings but had a greater fat thickness (0.15 cm greater; Griffin et al., 2007). There were no differences in the percentage of animals grading choice or higher or USDA YG between the two production systems. These results were similar to findings of Sainz and Vernazza Paganini (2004) where they found no difference between calf-feds and long-yearlings marbling score, USDA YG, and percent of carcasses grading choice or higher.

III. Long Yearlings

Forage Based Diet

Ruminants have the ability to convert fibrous feed sources that are not efficiently used by other livestock species into products such as meat, milk, and fiber that are valued by humans (Burns, 2008).

Over the past two decades, grain prices have steadily increased. Due to these increasing grain prices, there has been a move to add weight to cattle on forages prior to feedlot entry. It is logical to add weight to yearling cattle while they are on pasture because this is where they make economical gains (Lewis et al., 1989). An even higher gain on pasture is possible if yearlings are supplemented (Rolfe et al., 2011).

In order to counteract the higher grain prices while trying to add more weight to yearlings, producers have developed strategies to graze yearlings on grass longer. Traditionally, cow-calf pairs graze Sandhills upland range is normally restricted to summer grazing beginning in the middle of May and ending in the middle of October. Normally, once the grazing season ends, calves are weaned and then placed in a feedlot or fed harvested hay. Due to the high cost of producing and harvesting hay, many producers are extending the grazing season to help reduce the amount of harvested feed that is being fed. Because forage quality of dormant range is low, the grazing season can be extended by supplementing or high quality hay (Adams et al., 1994).

Sandhills Forages

The species composition of Sandhills upland range is very diverse. It can be a challenge after a multiple-season grazing approach to maintain the mix grass prairie characterized by its diverse mixture of warm and cool-season grasses, sedges, and forbs. The key warm-season species that contribute 50% to 80% of the composition of upland range are sand bluestem (*Andropogon hallii*) and prairie sandreed (*Calamovilfa longifolia*; Masters et al., 1990; Reece et al., 1996). The key cool-season grasses that are common in Sandhills uplands are needle-and-thread (*Heterostipa comata*) and prairie junegrass (*Koeleria macrantha*; Schacht et al., 2000). In order to maintain a species composition that is beneficial to upland range, timing of grazing during the grazing season is a critical management tool to ensure sustainable livestock production.

To maintain an upland range species composition, a study was conducted to examine changes in warm-season grasses and measure the yearling cattle responses in herds that were rotationally stocked or stocked at three rates (Anderson et al., 1997). Yearling gain was not affected by the stocking rate when cattle were rotationally stocked, but gain declined from 113 to 60 kg/acre when the stocking rate increased from 2.1 to 3.3 steers/acre using the continuous stocking method. As stocking rate increased across all treatments, ADG decreased. The grazing season was extended when a rotational stocking rate was used and had a relatively higher ADG and gain/acre than the continuous stocking method. There was also a greater change in species composition when the continuous stocking method was used which could potentially affect the long-term production of the site.

Meadows make up about 10% of the 4.8 million ha of the Nebraska Sandhills (Volesky et al., 2004). In contrast to the species composition of Sandhills upland range, introduced cool-season grasses, legumes, native sedges, and rush species make up a majority of the species composition of wet meadows (Ehlers et al., 1952). Wet meadows are primary used for harvest hay production, but may be grazed during the dormant season by yearling cattle when soil conditions are drier or the soil is frozen (Coady and Clark, 1993). By grazing during the dormant season, cattle will be harvesting growth that occurred after haying. Adams et al., (1994) found that by grazing meadows in the spring when the forage quality was higher and lactation was at its peak resulted in an increase in growth rates for the calves and greater BCS for the cows. This was also reported by Horney et al., (1996) when grazing meadows in the spring and summer.

Corn Residue

Due to the expansion of corn production in the recent years, corn residues have become a great feed resource for the beef cattle industry. Residues provide a cheap feed resource that is readily available in Nebraska. Grazing of the residue is the cheapest and most effective way to utilize the resource.

Since plants have reached physiological maturity when harvested, residues are low in protein and energy digestibility. However, corn residue is higher quality then winter native range and will require less protein supplementation (Clanton, 1989). Corn residue will also increase the number of days cattle are grazing and not consuming harvested forage. Calves grazing corn residue during November through December have gained an average of 0.51 kg/d and ranged from 0.22 kg/d to 0.74 kg/d in Nebraska (Klopfenstein et al., 1987).

When calves are turned out on corn residue, they will first select the grain, then husks and leaves, and then finally the stems or cob (Fernandez and Klopfenstein, 1989). However, grazing does not completely maximize the utilization of the corn residue which is normally between 20%-30% utilized. A majority of the residue is trampled, lost to the weather, or decomposed.

For calves, protein is the first limiting nutrient when grazing corn residue. Because CP and energy is low in residues, a protein supplement high in RUP is needed to increase gain of growing calves grazing residue. Distiller grains are a supplement that is high in RUP and energy. The supplementation of DDGS has been shown to have a quadratic response in gain when calves were supplemented at increasing levels while on nonirrigated corn residue (Gustad et al., 2006). A quadratic response to gain was also observed when steers grazed irrigated and nonirrigated corn residue and was supplemented at 0.3%, 0.7%, and 1.1% of their BW DM basis (Jones et al., 2014). Steers gained an average of 0.68, 0.92, and 0.96 kg/d, respectively, and having an optimum gain to intake response at intakes of 1.0% of BW on irrigated corn residue and 0.9% of BW on nonirrigated corn residue.

Finishing on Pasture

Forage finishing systems have been unsuccessful due to cattle grading poorly and meat having a grass flavor. Supplementing grain in pasture finishing systems is an alternative to the traditional finishing systems where cattle are finished in a confined feedlot (Griebenow et al., 1997). In order to finish cattle on grass in a reasonable number of days, energy needs to be supplemented. High fiber by-product energy sources are used to reduce the negative interaction associated when grains are fed in a high roughage diet. With this type of supplementation strategy, cattle will have the potential to grade and will be able to achieve this in a 70d finishing phase.

Cattle on pasture have been supplemented grain to reduce the amount of time the animals will require to finish in the feedlot. Steers that were finished using the grain-on-grass finishing system, required at least 30 more days to reach an Average Choice quality grade than steers that were finished traditionally, but they were a full quality grade higher than the traditionally finished animals (Griebenow et al., 1997). This was also illustrated when steers were fed for 101 days on either Tifleaf pearl millet or 90% corn and 10% animal fat supplementation on millet pastures (Maruri and Larick, 1992). Steers finished on the grain-on-grass treatment had greater marbling than steers finished in the feedlot.

Energy is the first limiting nutrient for cattle finished on forages. By supplementing energy, the protein supplied by of the forage will be used in the production of lean tissue. If excess energy is consumed by the animal, the animal will deposit the energy as fat. If energy in the form of soyhulls, rice bran, or corn gluten feed is supplement to cattle grazing high quality forages, the finishing phase can be started while the cattle are still in the pasture, initiating intramuscular fat deposition, resulting in a decrease time in the traditional feedlot phase and grain consumption (Griebenow et al., 1997).

Creep Feeding

Being able to supplement calves with creep feed while they are still growing, allows producers to add additional gain before weaning (Marlowe et al., 1965; Cundiff et al., 1966; Scarth et al., 1968; Holloway and Totusek, 1973; Stricker et al., 1979). Over a 10-year period, 821 Angus calves were studied to determine the effects of creep feeding. At 210 days of age, the calves that were creep fed were 15 kg heavier than non-creep-fed calves (Martin et al., 1981). Calves that were creep-fed had lower postweaning gains than non-creep-fed calves. Throughout the trial, creep-fed calves maintained the weight advantage over the non-creep fed calves that were present at weaning. These results were similar to the findings of Scarth et al. (1968) and Myers et al. (1999). Based on these results, if creep feeding is going to be used, male calves that are being placed directly into the feedlot after weaning are the only class of cattle that should be creep fed.

Heifer calves that were creep fed were lighter than male creep-fed calves, but were heavier than calves that were not creep fed (Martin et al., 1981). At weaning, creep-fed heifer calves were 10 kg heavier than non-creep fed calves. Postweaning gains were reduced by 0.11 kg/day for heifer calves. Heifers that were creep-fed showed a 10 kg advantage in weaning weight but a 7 kg disadvantage at 365 days of age when they were compared to the noncreep-fed heifers. This shows that postweaning gain is affected by creep feeding in heifers and heifers can lose weight going into the breeding season the following spring.

IV. Heifer Management Systems

Replacement Heifer Development

The second largest cost in a cow/calf enterprise is development of replacement heifers. This is due to the large amount of harvested forage that the heifer will consume and input costs during this time period. In order to offset this expense, several alternative heifer development systems have emerged to decrease the expense of harvested feed.

In order to offset the cost of developing heifers, many producers look to grazing dormant forage or crop residue when developing heifers. In two studies, heifers (n = 227 and n = 180, respectively) either grazed winter Sandhills range or corn residue, or eastern Nebraska winter range or corn residue with supplement to evaluate the effects of heifer development systems on growth and performance (Larson et al., 2011). In both experiments, prebreeding BW percentage of mature BW at breeding and pregnancy diagnosis were similar between the two treatments. However, heifer ADG was less for heifers grazing crop residue. The percentage of heifers that were pubertal at breeding, AI conception, and AI pregnancy rate, and final pregnancy rate were similar between the crop residue and winter range treatments. These results are similar to Weber et al., (2012) in that heifers developed on crop residue have similar reproductive performance to heifers developed on winter range. Heifer development costs did not differ between the two development systems. Developing heifers on crop residue may decrease ADG before breeding, but heifers developed on crop residue and dormant range have similar reproductive performance and development costs.

Historically, it was recommended to have heifers at a BW that was 66% of their mature weight before the first breeding (Patterson et al., 1992). However, recent studies have indicated that heifers that are <55% their mature BW at breeding have similar reproductive performance of their counterparts at a greater percentage of mature BW (Funston and Deutscher, 2004; Martin et al., 2008). This was supported when heifers were developed to 55% of their mature BW before a 45-d breeding season or to 50% of their mature BW before a 60-d breeding season (Martin et al., 2008). BW was greater for heifers developed to 55% their mature BW at prebreeding and pregnancy diagnosis. However, overall pregnancy rate did not differ (88.4%) between the two heifer groups.

Heifer Management

Over the years, heifer calves are priced for less money compared to steers due to their slow gains, efficiency, agitation of other cattle by showing estrus, and increased risk of pregnancy before entering the feedlot or injured (Dinusson et al., 1950; Cameron et al., 1977; Horstman et al., 1982). A management tool that has been used for decades to help improve heifer performance and behavior is spaying or ovariectomizing heifers. However, heifers that were spayed had lower performance on pasture and in the feedlot than heifers that were still intact (Ray et al., 1969). The Willis and the Kimberling-Rupp (Rupp and Kimberling, 1982) are tools that make spaying quicker and more economical to the producer.

Anabolic steroids are another way to improve heifer gains and efficiency while on pasture or in the feedlot. Steroids like Synovex-H have shown to improve gains and feed efficiency in both intact and spayed heifers (Ray et al., 1969; Goodman et al., 1982). Heifers that were implanted with Synovex-H had greater overall ADG and were more efficient than heifers that were not implanted (Garber et al., 1990). Heifers that were not implanted but spayed showed a decrease in ADG, feed intake, and feed efficiency. These findings were similar to research showing that in order for heifers to overcome impeded growth, they must be implanted with anabolic agents (Dinusson et al., 1950; Horstman et al., 1982; Shoop et al., 1984).

Implanting heifers also increased carcass characteristics. Heifers that were implanted and spayed had carcass characteristics of increased adjusted live weight at slaughter, adjusted HCW, and adjusted REA. Implanting decreased marbling and quality grade and adjusted backfat, KPH, YG, and dressing percent were not affected (Garber et al., 1990). Results show that in order to increase heifer growth and efficiency, implanting and spaying of female cattle is necessary.

Replacement Heifer Development on Distiller Grains

With the price of feedstuffs continuing to increase, producers continue to use alternate feeds in rations to meet nutritional requirements of cattle while creating the cheapest ration possible. With the increase in ethanol production, distiller grains become an economical source of protein and energy. In the Midwest, replacement heifers are developed on forage based diets supplemented with protein and energy. With the increase in ethanol production in the Midwest, distiller grains are viable supplement to include in the rations to meet energy and protein needs of the replacement heifers.

Martin et al., (2007) developed replacement heifers on a forage based diet while supplementing either DDG or control (corn gluten feed, whole corn germ, and urea). Heifers that were supplemented with DDG had a higher conception rate to AI (75.0 vs 52.9%) than control heifers. Distiller grain supplemented heifers also had a greater AI pregnancy (57.0 vs 40.1%) than control heifers. Heifers that were supplemented distiller grains during their growth and development stages showed increased AI conception and pregnancy rates compared to control supplemented heifers.

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CHAPTER II

Use of Distiller Grains in Alternative Heifer Systems

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ABSTRACT: A 2-yr study compared performance and carcass characteristics between a traditional and an alternative yearling finishing systems. Heifers were weighed and randomly assigned to one of two groups. Control heifers grazed upland sandhills range for 129 d followed by feedlot finishing for 103 d (CON, n = 24/yr). In the alternative system, self-fed heifers grazed upland sandhills range for 138 d with ad libitum access to a self-fed dried distillers grains based supplement (SF, n = 24/yr). Data were analyzed as a completely randomized design with treatment as a fixed effect, year as a random variable, and pasture as the experimental unit. The SF heifers had a one-third greater stocking rate compared to CON, because the supplement (4.63 kg DM/heifer/d) was calculated to replace grazed forage. Residual forage was similar ($P = 0.66$) between treatments. Heifers were harvested when twelfth rib backfat was visually estimated to be 1.27 cm. Backfat at harvest was different ($P = 0.02$) so data were adjusted to a 28% empty body fat. The SF heifers had greater ADG ($P < 0.01$) and ending BW ($P < 0.01$) on pasture, but CON heifers had greater HCW ($P < 0.01$) and greater final BW ($P < 0.01$). There was greater G:F ratio on grass($P < 0.01$) and during the feedlot phase ($P < 0.05$) for SF heifers. Marbling score and LM area were greater ($P < 0.01$) for CON heifers. Total cost tended to be higher for CON heifers than SF heifers ($P = 0.07$). Self-fed heifers generated less revenue than CON heifers (P = 0.09), but had lower breakeven ($P = 0.31$). However, SF heifers reached market weight in 94 fewer d than CON heifers while having similar performance. This alternative production system may provide a viable option for marketing heifers in a cow/calf or yearling enterprise.

Key Words: distiller grains, heifer, alternative system

Introduction

With the increased production of ethanol in the Midwest, there has been an increase in ethanol byproducts available to producers. Byproducts, like distiller grains, can be a high quality feed for cattle even in forage-based diets. Distiller grains are high in digestible fiber, protein, fat, and low in starch (Lodge et al., 1997; MacDonald et al., 2007). If distiller grains are included in the diet at 15% or less, they are considered to be a protein supplement, but if they are included in the diet at more than 15%, they are considered to be a source of both protein and energy (Stalker et al., 2010). By being able to be fed as an energy and protein source, distiller grains allow producers to use this feedstuff in a variety of different ways.

Traditionally, many commercial producers select replacement heifers at weaning time. Replacement heifers at this time are normally selected on structure and weight. Producers normally select heifers that are heavier and these heifers tend to be older or have dams that have greater milk output. By selecting older calves, they usually exhibit estrous cycles earlier and potentially produce a calf earlier in the calving season. However, producers take on several risks at selecting replacement heifers by this method. They risk heifers increasing the overall mature cow frame size. In addition, overweight, fat heifers risk fat being deposited in the udders and decreased fertility (Ritchie et al., 2002). This could result in a decrease in calf crop and lowering average weaning weights.

Extending the time when producers select replacement heifers, producers will be able to choose heifers that better fit their herd and system. Producers will be able to select heifers on factors other than just BW such as disposition, structure, femininity, and puberty. By having more criteria to select their replacement heifers, producers will be able to choose replacement heifers that will better match their management system.

Because of this, producers will have to develop heifers on a diet that is cost effective in order to keep the heifers in the herd for a longer period of time. By utilizing grazed forages instead of harvested forage, producers will be able to minimize production costs by decreasing feed costs. Once heifers are selected as replacements, producers are faced with a dilemma of what to do with the heifers that were not selected as a replacement heifer. Currently producers have the option of selling the heifers as nonpregnant, placing them in a yearling system, or placing them into a feedlot. With the availability of ethanol byproducts, it allows producers to use alternative heifer feeding/development systems when selecting and culling replacement heifers. The objectives of the experiment were: 1) to compare heifer performance and carcass characteristics in two systems post-weaning, 2) to evaluate the economics of the heifer systems, and 3) to assess the pasture use and conditions when heifers were either finished on vegetative pasture with a high energy supplement or allowed to graze summer pastures without supplementation followed by a finished feedlot phase.

Materials and Methods

The experiment was conducted at the University of Nebraska Barta Brothers Ranch, located near Rose, NE. All procedures and facilities utilized were approved by the University of Nebraska-Lincoln Institutional Animal Care Program.

In a two year study, 96 crossbred heifer yearlings were used in a completely randomized design with two treatments: Control (CON) and Self-fed (SF). Control treatment heifers (n = 24/yr) were provided a summer grazing period with no supplement followed by a feedlot finishing period. Self-fed heifers (n = 24/yr) had ad libitum access to a DDGS-based concentrate that was offered in a self-feeder during the grazing season. Upon arrival, heifer calves were weighed, vaccinated for respiratory disease, implanted with Synovex-H (Pfizer Animal Health), and dewormed with Ivomec (Merial Animal Health). Once they were weighed, heifers were assigned randomly to treatments. Two day consecutive BW measurements were recorded and averaged to establish initial weights (CON = 312 kg; SF = 307 kg).

Both CON and SF heifers were placed on native upland Sandhills pastures of similar topography and forage composition. The primary species composition of these Sandhill pastures were warm season grasses including sand bluestem (*Andropogon hallii*), prairie sandreed (*Calamovilfa longifolia*), little bluestem (*Schizachyrium scoparium*), and switchgrass (*Panicum virgatum*) but also included some cool season grasses including smooth brome (*Bromus inermis*), needleandthread (*Hesperostipa comata*), and sedge (*carex heliophilai)*. Control heifers had a stocking rate of 0.61 AUM/ac while SF heifers were stocked at 0.87 AUM/ac based on the assumption that the distiller grain supplement would replace one third of the grazed forage consumed. Each treatment grazed from mid-May to the end of their treatments respective grazing period. Forage stubble height was measured at the end of each grazing period by using the plate and yard stick method. To measure residual height, it was done by lowering the plastic disk towards the forage until about 10% of the leaves and stems were touching the disk. At this point, the yardstick was used to measure the forage height at that level (Sharrow, 1984). Residual forage measurements were averaged with other measurements from the same treatment.

Cattle were transported to a commercial abattoir (Tyson Fresh Meats, Dakota City, Nebraska) when 12th rib backfat were estimated to be at 1.27 cm. Hot carcass weights, USDA marbling scores, 12^{th} rib fat depth, LM area, and KPH were recorded. Final live weight was estimated by dividing individual carcass weight by a 62% dressing percentage.

Control (Grazing Followed by Feedlot Phase)

Control heifers grazed from mid-May to mid-September annually and received a free choice mineral supplement (0.11 kg/hd/d). In September, heifers were weighed and transported to the Haskell Agricultural Laboratory (HAL) feedlot located near Concord, NE. Upon arrival heifers were vaccinated for respiratory disease, treated for internal and external parasites with Ivomec (Merial Animal Health), and re-implanted with Synovex-H (Pfizer Animal Health). Prior to collecting two day consecutive weights, cattle were limit fed grass hay to eliminate variation and minimize gastrointestinal fill (Watson et al., 2013). Cattle were transitioned over a period of 21 days to a final finishing diet composed of 75.25% dry rolled corn, 18.0% corn silage, 3.5% liquid supplement, 3.25% SBM, on a DM basis.

Self-Fed (Ad libitum DDGS Based Feed During Grazing)

The SF heifers grazed from mid-May to mid-October and had ad libitum access to a dry distiller grains plus solubles (DDGS) based supplement (Table 1). The DDGS based supplement composition was 75% DDGS, 20% whole shelled corm, and 5% commercial supplement in year one and 75% DDGS, 20% soy hull pellet, and 5% commercial pellet in year 2. The commercial pellet was composed of minerals and an ionophore. Self-feeders were located near pasture water sources. This was done to reduce trampling of areas and minimize the effect of creating a blowout. The stocking rate was increased by one-third in anticipation that the DDGS would substitute for some of the grazed forage. Heifers were harvested on October 26 and October 16 for Years 1 and 2, respectively. Because 12th rib backfat was significantly different from the control heifers at harvest (1.47 cm and 1.07 cm respectively; $P < 0.04$), performance and carcass data were adjusted to a common empty body fat (EBF) of 28% (Guiroy et al., 2001).

Economics

All feed and cattle prices were based on 2011 and 2012 actual purchase prices. Total cost for each treatment included initial heifer cost, supplement cost, pasture rent, feedlot diet, yardage, and implant cost. Feedlot yardage was allocated at $0.40/hd/day. Yardage while grazing pasture was assessed at $0.05/hd/day which accounted for fencing, maintenance, watering, and checking the creep feeders. The feedlot diet cost $3.58/hd/d. Pasture rent was $19.60/AUM based on the average of pasture rent prices for central Nebraska (http://agecon.unl.edu/cornhuskereconomics, 2013). The DDGS mix was priced at $202/ton (2011) and $285/ton (2012). An additional $17/ton was added for delivery and handling of the distiller grains. Revenue was calculated by multiplying the carcass price by the carcass weight. Profit or loss per heifer was calculated by subtracting the feed, grazing, and yardage costs from the revenue. The carcass breakeven price was calculated by dividing the total cost by the hot carcass weight (HCW).

Data were analyzed as a completely randomized design with the experimental unit being the pasture. Treatment was analyzed as a fixed effect and year was analyzed as a random variable.

Results and Discussion

Performance

Heifer performance and days on grass or in the feedlot are presented in Table 2. The SF treatment heifers had greater ADG ($P \leq 0.01$) while on pasture as a result of the treatment. Gain for SF heifers was 1.46 kg/d, while CON heifer ADG was 0.78 kg/d during the pasture phase and 1.62 kg during the feedlot phase (1.15 kg/d; combined grazing and feedlot phases for CON heifers, Table 3). Self-fed heifers consumed 4.59 kg/hd/d/yr of the DDGS supplement. There was no difference in forage appraisal between the two treatments ($P = 0.33$). Horn et al., (1995) and Bumpus (2006) also observed similar results when cattle were fed an energy supplement while grazing pasture. The cattle's forage DMI decreased due to the supplement replacing part of the forage that was consumed. MacDonald et al., (2007) also confirmed that DMI decreased for calves supplemented an energy concentrate by stating that stocking rates could be increased by 10-20% when supplemented DDG. Self-fed heifers were harvested approximately 93 d before their CON contemporaries. Control heifers had a lower G:F on grass (0.09 kg; $P \leq 0.01$) and in the feedlot (0.15 kg; $P = 0.04$) than SF heifers (0.16 kg, 0.16 kg respectively). The CON heifers tended to produce heavier carcasses than SF heifers (358 kg vs 323 kg; $P \leq 0.01$). A greater hot carcass weight for CON heifers resulted in final calculated live weight being greater ($P \leq 0.01$) than SF heifers (577 kg, 520 kg respectively; Table 3). These results were similar to the findings of Griffin et al., (2007) where they found that calf-feds which are similar to the SF heifers had a lighter HCW than the long-yearlings or CON heifers in the study.

Carcass Data

After carcass data were adjusted to a 28% empty body fat, there was a difference ($P \leq 0.01$) in USDA marbling scores, calculated yield grade, and LM area (Table 4). Control heifers had higher marbling score but had a lower calculated yield grade then SF heifers (2.85 vs 3.11 respectively; $P \leq 0.01$). However heifers on the control treatment had a larger ($P \leq 0.01$) LM area compared to SF heifers ($P \leq 0.01$).

Economics

Economic analysis is presented in Table 5. There is a price difference between the pasture cost ($P = 0.03$) and yardage ($P = 0.04$) on grass between the two treatments. This difference is because CON heifers grazed an allocated pasture that was one third larger than the SF heifers. The total heifer cost tended to be higher for CON ($1674.55) than for the SF heifers ($1243.26; $P = 0.07$). The greatest cost for SF heifers, besides purchase price ($981.70), was the cost of DDGS ($223.40/ton). The CON heifers produced more total revenue ($1442.90) compared to SF heifers ($1158.24) because they yielded heavier, higher quality graded carcasses ($P = 0.09$). CON heifers had a breakeven of $237/cwt while the SF heifers had a breakeven of $202/cwt on a HCW basis.

To help offset the high cost of supplement in the SF system, producers can develop strategies to limit supplement intake of the heifers. By restricting intake, heifers would only be able to consume a limited amount of the supplement per day or per week. This would allow producers to compensate for the high cost of the supplement. Potential ways of restricting intake are limiting heifers access to the feeders, only providing a week's worth of the supplement in the feeder, or adding salt to the supplement. By restricting the amount of supplement the heifers consume, could potentially increase the profitability of the system.

Implications

By providing an energy supplement, it allowed stocking rate to be increased by one-third while keeping residual forage similar. This alternative production system could provide producers another way to add an enterprise to their operation by being able to add value to their non-pregnant females.

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Table 1. Composition of concentrate mixture offered to Self-fed heifers.

Ingredient[1]	Year 1	Year 2
DDGS	75	75
Whole Shelled Corn	20	---
Soy Hull Pellet	---	20
Commercial Pellet[2,3]	5	5

[1] % of supplement DM
[2] Contained minerals and ionophore (Bovatec)
[3] Supplement intake: 4.59kg/hd/d/yr (DM)

Table 2. Performance and forage attributes of Control and Self-fed heifers while grazing pasture.

	Actual				Adjusted[1]			
Item	Control	Self-Fed	SEM	P-value	Control	Self-Fed	SEM	P-value
Initial BW, kg	312	307	8.99	0.33	312	307	8.99	0.33
Off grass BW, kg	412	553	9.62	<0.01	412	520	5.91	<0.01
ADG, kg/d	0.78	1.46	0.05	<0.01	0.78	1.54	0.04	<0.01
Days on grass	128.5	169	6.75	<0.01	128.5	138	8.14	0.17
Estimated forage residual, cm	16.41	16.08	1.68	0.33	16.41	16.08	1.68	0.33
Days in feedlot[2]	97.47	---	---	---	103	---	---	---

[1] Data adjusted to 28% empty body fat (Guiroy et al., 2001)

[2] Feedlot diet composition (DM): (75% DRC, 18% corn silage, 3.5% liquid supplement, 3.25% SBM)

Table 3. Performance and carcass weight of Control and Self-fed heifers.

	Actual				Adjusted[1]			
Item	Control	Self-Fed	SEM	P-value	Control	Self-Fed	SEM	P-value
HCW, kg	358	339	10.91	<0.01	358	323	8.42	<0.01
Final BW, kg	570	553	17.65	0.03	577	520	13.59	<0.01
System ADG, kg[2]	1.15	1.46	0.10	<0.01	1.14	1.54	0.04	<0.01
Feedlot ADG, kg[3]	1.62	1.46	0.15	<0.01	1.59	1.54	0.09	0.46
G:F Grass	0.09	0.15	0.01	<0.01	0.08	0.16	0.01	<0.01
G:F Feedlot[4]	0.15	0.15	0.01	0.92	0.15	0.16	0.21	0.04

[1]Data adjusted to 28% empty body fat (Guiroy et al., 2001)
[2] Using days in system: (Control: May-December; Self-fed: May-October)
[3]Using days in system: (Control: September-December; Self-fed: May-October)
[4] Feedlot DMI: 10.84 kg/d

Table 4. Carcass characteristics of Control and Self-fed heifers while grazing pasture.

	Actual				Adjusted[1]			
Item	Control	Self-Fed	SEM	P-value	Control	Self-Fed	SEM	P-value
% EBF[2]	27.26	29.01	0.34	<0.01	28	28	---	---
Marbling Score[3]	457	431	9.02	0.06	464	387	9.16	<0.01
YG	2.80	3.36	0.15	<0.01	2.85	3.11	0.11	<0.01
LM Area, cm	33.10	31.01	0.61	<0.01	33.38	29.46	0.84	<0.01

[1] Data adjusted to a 28% empty body fat (Guiroy et al. 2001)
[2] Original EBF %: (Control 27.26; Self-fed: 29.01)
[3] Marbling Score 500 = Modest (Choice), 400 = Small (Choice), 300 = Slight (Select)

Table 5. Economic analysis of Control and Self-fed heifers while grazing pasture.

	Actual				Adjusted[1]			
Item	Control	Self-Fed	SEM	P-value	Control	Self-Fed	SEM	P-value
Initial Heifer Cost, $/hd	994.70	981.70	---	---	994.70	981.70	---	---
Dried Distillers, $/hd[2,3]	---	519.72	---	---	---	223.40	---	---
Pasture Cost, $/hd[4]	83.67	73.35	1.55	0.03	83.67	32.41	1.70	0.03
Feedlot Diet Cost, $/hd	351.73	---	---	---	524.86	---	---	---
Yardage Feedlot, $/hd[5]	38.99	---	---	---	58.00	---	---	---
Yardage Grass, $/hd[6]	6.43	8.45	0.34	0.01	6.43	3.76	0.41	0.04
Implants, $/hd	2.00	2.00	---	---	2.00	2.00	---	---
Total Cost	1474.45	1584.92	135.72	0.45	1674.55	1243.26	129.60	0.07
Revenue $/hd[7]	1613.16	1403.33	46.16	0.03	1442.90	1158.24	29.54	0.09
Breakeven $/hd[8]	186.74/cwt	211.90/cwt	13.53	0.36	237.26/cwt	201.59/cwt	17.09	0.31

[1] Data adjusted to 28% empty body fat (Guiroy et al., 2001)
[2]Base price of distillers year one=$202/ton + $17/ton delivery charge
[3]Base price of distillers year two=$285/ton + $17/ton deliver charge
[4]Pasture costs based on Cornhusker Economics for each year (2011-$18.30/AUM) (2012-$20.89/AUM)
[5]Number of days in feedlot X $0.40 hd/day
[6]Number of days on grass X $0.05 hd/day
[7]Carcass price X carcass weight
[8] Total Cost / HCW

APPENDIX

Student Participation in Companion Animal Nutrition Group Projects Lead to Development of Professional Skills

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ABSTRACT: Applying nutrition concepts and the scientific method in a practical way can increase student learning. Group projects can be a way for students to collaborate with each other on assigned projects that are more complex and challenging than if the project was assigned to an individual. University of Nebraska-Lincoln students enrolled in a Companion Animal Nutrition course were required to complete a group project designing and conducting their own research project. At the completion of the project, students were required to complete an exit survey ranking items on a 1 (strongly disagree) to 5 (strongly agree) Likert-type scale. Students (n = 66) indicated that they had a better appreciation for nutrition research after they completed the project (mean = 3.97). Students expressed that the nutrition projects allowed them to apply what they had learned in class to their projects (mean = 4.09). However, groups had mixed opinions when they were asked if members from their group equally contributed to the completion of the project (mean = 3.56, SD = 1.44). Groups did indicated that the group projects improved their communication skills (mean = 3.20) and critical thinking skills (mean = 3.68) by completing the group project. The group projects allowed learning activities that built upon the core objectives of the class.

Key Words: companion animal, nutrition, education, collaboration

Introduction

Group projects allow students to develop skills that they will use every day in the professional world (Caruso and Woodley, 2008; Mannix and Neale, 2005). By developing professional skills in the classroom, students are better prepared for the careers they are acquiring after graduation. Breaking up complex tasks, time management, and developing stronger communication skills are all developed by students while working on group projects. These projects also allow students the opportunity to develop collaborative efforts that help students work as a unit or become team players. Collaboration skills are developed by students to tackle more complex problems than they could complete on their own, to view other group member's perspectives, and to pool everyone's knowledge to make educated decisions. This allows students to become more comfortable when working with peers on projects that may be assigned to them in the future. Group projects also give students a sense of community or connectedness (Ouzts, 2006; Rovai, 2002). This sense of community and connectedness gives students fulfillment when taking classes online or in person (Williams et al., 2012).

More complex and challenging projects can be assigned to groups than if the project was going to be completed by an individual (Carnegie Mellon, 2014a). This challenges students to become critical thinkers as more than one way may be the correct way to complete the project. Students must interact and use other students within their group as a resource to complete the project. Group projects also allow professors to assign projects that encompass a majority of the learning objectives of the course. This not only allows students to apply what they have learned throughout the semester, but can be used as an indicator of student understanding.

Students may find animal nutrition concepts challenging. The goal of this project was to ask students to apply class concepts to design and conduct a small scale nutrition research project. An evaluation was done to determine if the project resulted in students applying class concepts, learning research methodology, and employment skills.

Materials and Methods

Course Enrollment

Companion animal nutrition is an upper level course offered to undergraduate students with a prerequisite of a general animal nutrition course. The course is offered in an on campus traditional lecture format and via distance. Course enrollment was 53 for the in person section and 35 for the distance sections. Over the two semesters, data was collected (Spring 2012 and 2013). Students enrolled in the course are primarily juniors and seniors. They include mostly Animal Science majors, but are also Fisheries and Wildlife, Veterinary Medicine and Biomedical Sciences, Food Science, and Applied Science majors.

While enrolled, students are required to participate in a group project where they design and conduct a companion animal nutrition research study. The objectives of this project were to demonstrate the steps required to conduct a nutrition experiment, identify scientific resources, and define a problem or issue to be evaluated related to companion animal nutrition. After identifying the issue, they developed a plan to answer the question that they have proposed. Students first turned in an initial proposal for review by the instructor before moving forward with the project. Students are required to turn in several progress reports along the way to track progress throughout the semester. Final papers were expected to be in journal article format with a title page, abstract, introduction, material and methods, results and discussion, literature cited, and tables.

A group mentor was identified for each group. Mentors were identified by either the group or the instructor and included graduate students, pet food industry professionals, and zoo keepers. The mentor's role was to help the group determine the best plan to answer their hypothesis and conduct their experiment. The mentor may also provide the group with additional support during the completion of the project such as access to animals. The research project was conducted throughout the semester the students were enrolled in the class. Numerical data was collected through each project. Students were required to compare their results to published literature to draw conclusions on the validity of their hypothesis once the project was finished. Once completed, the projects were graded and students completed a survey based on the project, group members, and its results.

Project Evaluation

An evaluation tool was developed to be completed by undergraduate students at the end of the semester. The survey first asked demographic information. It included the semester in which they were enrolled in the class, year in school, and if they were completing the class online or in-person.

In addition, students were asked to respond based on the five point Likert-type scale (5 = strongly agree, 4 = agree, 3 = neither agree nor disagree, 2 = disagree, 1 = strongly disagree) to a series of questions. Survey questions were designed to obtain feedback from students on how the group project was completed and how each student interacted with other members of the group, mentors, and instructors to complete the project. The procedures of the survey were reviewed by the University of Nebraska-Lincoln's Institutional Review Board (IBR).

Statistical Analysis

The data was analyzed using the mixed models procedure of SAS (Cary, NC). The survey was analyzed using class (in-class vs. online) as the variable. There were no differences found in student responses regarding if they took the class online or in-person, so the data for all students were combined.

Results and Discussion

Out of the 40 students enrolled in the course in 2012, 30 students (75%) returned the survey and 36 students (77%) returned the survey out of 47 enrolled students in 2013. Majors of students completing the survey were Animal Science (61%), Fisheries and Wildlife (27%), Veterinary Science and Biomedical Sciences (7.5%), Food Science (3%), and Applied Sciences (1.5%) majors. The types of projects conducted included surveys on pet food buying trends and consumer knowledge of pet foods, palatability and preference studies in dogs, cats, and zoo animals.

Students indicated that they found their mentor helped (mean = 3.64, SD = 1.19) with their projects (Table 1). However, there was wide variation in student responses. Students were only required to meet with their mentor once during the semester. Some students indicated having difficulties contacting their mentor or setting up times that would work for both the mentor and group members to meet. After the first year, students were given additional advice on how best to communicate with their mentor. Students suggested that they should have met with their mentor more times so they would have gotten more professional guidance on the assignment. Other groups worked more directly with their mentor throughout the conduct of the experiment.

Throughout the semester, there were multiple checkpoints in which students had to turn in part of their project. Students agreed (mean = 4.32, SD = 0.99) that they liked having several checkpoints throughout the semester. They stated that the checkpoints allowed them to stay on track with the group project and make progress on it throughout the semester. The checkpoints also allowed for the students to get feedback on their project to improve their final submission. When asked if they felt that the expectations of this assignment were clearly explained, student agreed (mean = 3.98, SD = 1.10). Students were provided a handout with the layout of each section of the paper and example citations. However, some students commented on their surveys that they would have liked it if there were clearer announcements about how the checkpoints should be completed but they thought by having checkpoints was a good way to keep them on top of their research project. This allowed them to stay on task and not get behind and complete the project right before it was due.

The research projects allowed students to apply what they had learned in class to their nutrition project (mean = 4.09, SD = 0.92). Students commented that reading research articles that covered material that was discussed in class allowed them to validate the lecture topics. The research project allowed students to see where the information comes from.

Groups had mixed opinions (mean = 3.56, SD = 1.44) when asked if members from their group equally contributed to the completion of the project. Students stated that it was hard to find time to meet with group members if their group was compiled of online and in-class group members. Since students were both enrolled online and in-class, they said it was hard to develop working relationships with your group members when you do not see them in class or they were difficult to communicate with. Hiltz et al., (1997) also saw similar results when comparing virtual classrooms to traditional classrooms. They stated that students were able to make friendships with students taking the class via a virtual classroom, but it was harder to establish a working relationship between these students.

The instructor set up dates to meet with every group prior to the start of the group projects and again halfway through the semester. Students agreed (mean = 3.92; SD = 1.18) that meeting with the instructor was helpful in completing the project. Students felt that this meeting got them off on the right foot and helped them stay on task with their project. The instructor gave them insight on how to go about the project and how to correctly conduct the experiment or survey. Instructors who express the value of a group project, provide insight to the group, and try to limit negative aspects of group projects may positively affect students' attitudes toward group work (Chapman, 2001).

Students indicated that the group project improved their communication skills (mean = 3.20, SD = 1.13) and critical thinking skills (mean = 3.68, SD = 1.11; Table 2). Students commented that it was hard to find time to meet or contact students that were not in the same section of class they were enrolled in. This lack of communication made it difficult at times to complete the tasks with all group members present. This however made students assess the situation and develop a plan to make sure that all group members were involved and actively participating in the project. Coers et al. (2010) indicated that group communication is the foundation of a successful group. By improving group communication, students will be able to better prepare themselves for employers.

Students identified that they have a better understanding of how to support their ideas with research after the completion of the project (mean = 3.76, SD = 1.04). Several students commented that they liked how they got to pick the topic and design the experiment that they were going to conduct. They enjoyed being able to do the hands on research themselves and see how their results correlated with other studies that were similar. Students indicated that they had a better understanding of the application of the scientific method following their project (mean = 3.57, SD = 1.17). Students found that they enjoyed completing the research while trying to support their hypothesis. This allowed students to develop a better understanding on how the scientific method works in order to complete their project.

Felder and Brent (1996) indicated that when using cooperative (team based) learning properly in college settings enhances motivation to learn, retention of knowledge, depth of understanding, and appreciation of the subject being taught. Students agreed (mean = 3.97, SD = 1.12) that they had a better appreciation for nutrition research after they had completed this project. It allowed them to learn about how important nutrition is to an animals and why research needs to be done in order to ensure that we have products that are healthy and beneficial to our pets. Students also indicated that the research project was a great way to get them accustomed to research by having them come up with their own research experiment, conduct the experiment, and have them write up their findings so they can be presented to their peers.

The project allows students to see what type of research goes on in the pet industry. Being animal science majors, many of the student's careers could involve research within the industry. These projects give students hands on experience of the research that is being conducted in the pet industry. Students agreed (mean = 3.55, SD = 1.17) that the project related to their future career and stated that it was beneficial to their future (mean = 3.33, SD = 1.19). After completion of the course, a student interviewing for veterinary school indicated explaining her project was well received by the interview committee. Other students have discussed this experience in interviews as well.

Overall, students commented that the project was a worthwhile experience. Several students stated that they liked that they got to pick the animals that they were able to do the research trial on and that this type of project helped them build upon the foundation that was developed in lecture. Students also liked the project because they were actually able to conduct the experiment themselves. By being able to conduct the experiment, they were able to learn about the scientific method and develop skills to properly conduct a research trial.

Summary and Implications

Group projects are a great way for professors to develop learning activities that build upon the core objectives of a class. The nutrition projects allowed students to develop skills that they will continue to use throughout college and their career. These skills allow students to become more confident in themselves and in completing complex tasks within a group setting. By learning how to collaborate with each other, students were able to collaborate with each other and meet deadlines. These skills will not only be needed during their careers, but in their everyday lives. Group projects allowed students to not only grow themselves as individuals, but also as members of a group.

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Table 1. Effects of student participation in a group project while enrolled in companion animal nutrition.		
Item	**Mean**	**SD**
I found the mentor to be helpful.	3.64	1.19
I liked having multiple checkpoints throughout the assignment.	4.32	0.99
I felt that the expectations of this assignment were clearly explained.	3.98	1.10
I applied the concepts we learned in class when completing this assignment.	4.09	0.92
The members in my group equally contributed to the completion of this project.	3.56	1.44
Having a day to meet with the instructor was helpful in completing my project.	3.92	1.18
This project was s worthwhile experience.	3.55	1.20
How many times did you meet as a group outside the class?	2.86	1.07
Approximately how much time did this project take outside of class time?	2.58	0.93
Ranked on a scale of 1-5: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree		

Table 2. Impact of group project the development of student's profession skills and future decisions.

Item	Mean	SD
I had to improve my communication skills to complete this project.	3.20	1.13
Completing the project improved my critical thinking skills.	3.68	1.11
I better understand how to support my ideas with research.	3.76	1.04
I have a better understanding of the application of the scientific method.	3.57	1.17
After completing this project, I have a better appreciation for nutrition research.	3.97	1.12
I can see how completing this project relates to my future career choices.	3.55	1.17
Completion of this project will be beneficial to my future career.	3.33	1.19
Completing this course/project changed my perception of research in the pet food industry.	3.46	1.15
I am considering graduate school after completion of this course.	2.53	1.43
I am more interested in a career with research after completing this course.	2.38	1.20

Ranked on a scale of 1-5: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree