MinnesotaCorn
RESEARCH & PROMOTION COUNCIL

FINAL REPORT

PROJECT TITLE: Evaluation of long-term reproductive and lactation performance of dairy heifers fed increasing dietary concentrations of reduced fat distillers dried grains in replacement of forage during pubertal development**.**

PROJECT NUMBER: This project is an extension of # AURI AIC211.

PRINCIPAL INVESTIGATOR AND CO-INVESTIGATOR(S):

Principal Investigator:
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ABSTRACT

Provide a project summary describing an overview of the project including principle findings. Include a statement on how the project was of benefit to corn farmers.

The objective of this study was to determine the effect of increasing the inclusion rate of distillers dried grains (**DDGS**) in replacement of forage in limit-fed diets fed during the prepubertal growth phase on the long-term reproductive and lactation performance of dairy heifers. Additionally this project funding allowed us to expand the original feeding project from 36 heifers to 48 heifers. A 16-wk randomized complete block design study was conducted using 48 Holstein heifers (199 ± 2 d of age) with three treatments. Treatments were 1) 30% DDGS (**30DG**), 2) 40% DDGS (**40DG**), and 3) 50% DDGS (**50DG**) with the remainder of the diet consisting of grass hay and 1.5% mineral mix. Heifers were individually limit-fed using Calan gates at 2.65, 2.50, and 2.35% of body weight (**BW**) on a dry matter (**DM**) basis for 30DG, 40DG, and 50DG, respectively. After completing the feeding trial heifers were fed a common diet according to regular herd management. Data on reproductive performance and milk

production for the first three months of lactation were collected for each heifer from dairy herd records. At 3 wk prepartum and at calving, BW, frame measurements, and body condition score (**BCS**) were recorded. There was a linear tendency for age at first service to decrease with increasing amounts of DDGS; however, there were no differences in any other reproductive or frame measurements. There was a treatment by month effect for somatic cell count; however, there were no other differences for any of the lactation parameters measured during the first 90 days of first lactation. Results demonstrate that producers can feed DDGS at up to 50% of the diet to peripubertal heifers without negative consequences to long-term performance. This benefits corn growers by encouraging the use of DDGS for dairy heifer feeding.

INTRODUCTION

Provide background information related to the project including such item as the problem statement, knowledge gaps, and relevant previous work completed on this issue.

The optimal growth rate and feeding strategy of growing dairy heifers to maximize reproductive and lactation performance has been well researched. Increasing ADG in order to shorten the length of the rearing period and decreasing age at first calving has been shown to result in an earlier return on investment (Ettema and Santos, 2004). However, increasing the ADG of growing dairy heifers has been demonstrated to have a negative impact on mammary development and lactation performance (Van Amburgh et al., 1998; Zanton and Heinrichs, 2005; Meyer et al., 2006).

Feeding heifers high concentrate diets, but restricting ADG during the prepubertal has been demonstrated to maintain milk production when compared to high forage diets (Carson et al., 2000; Zanton and Heinrichs, 2009). Manthey et al. (2016) limit-fed diets with increasing inclusion amounts of DDGS and found no differences in growth performance or ADG. Anderson et al., (2015) limit-fed heifers a corn and soybean product based control diet, low-fat DDGS, or high-fat DDGS and found that heifers fed the DDGS diets had similar or improved milk production.

There has been very limited research examining the effect of limit-feeding diets with DDGS as the primary concentrate ingredient during the prepubertal growth period of dairy heifers on subsequent reproductive and lactation performance. Therefore, the main objective of this research was to evaluate the effect of increasing the inclusion rate of DDGS in replacement of forage in limit-fed diets on the long-term reproductive and lactation performance of dairy heifers. It was hypothesized that increasing the inclusion rate of DDGS would result in a maintained or improved reproductive and lactation performance.

OBJECTIVE AND GOAL STATEMENTS

The objective of this study was to evaluate the effect of increasing the inclusion rate of DDGS in replacement of forage in limit-fed diets on the post-trial reproductive and first lactation performance of dairy heifers. Additionally this funding allowed for the expansion of the original project from 36 to 48 heifers, increasing our statistical power and strength of the experiment.

MATERIALS AND METHODS

As appropriate, describe the site(s), experimental design, and other relevant methodology used in completing the project.

All procedures and animal use was approved prior to the start of the study by the South Dakota Institutional Animal Care and Use Committee.

Experimental Design

Forty-eight Holstein heifers (199 ± 2 d of age) were used in a randomized complete block design with three treatment diets. The feeding period lasted for 16 wk, beginning during the prepubertal period. Treatment diets (Table 1) were: 1) high forage with 30% of diet as DDGS (30DG), 2) moderate forage with 40% of diet as DDGS (40DG), and 3) low forage with 50% of diet as DDGS (50DG) on DM basis. The DDGS utilized had fat partially removed and contained moderate concentration of fat (7.8% of DM) among DDGS produced throughout the ethanol industry. The forage portion of the diets consisted of grass hay. The amount of feed offered was determined as a percentage of BW and decreased with increasing concentrations of DDGS in order to allow for similar intakes of energy across treatments. Diets were fed at 2.65, 2.50, and 2.35% of BW for 30DG, 40DG, and 50DG, respectively (DM basis). Diets were formulated using the NRC (2001) to provide similar energy intakes when fed to a 250 kg BW Holstein heifer. Heifers were fed individually using a Calan gate feeding system (American Calan Inc., Northwood, NH). Nutrient composition and average intakes are also provide in Table 1. Details regarding diet formulation and nutrient analysis are described in previous reports. During the feeding period, growth performance, rumen fermentation, nutrient digestibility, metabolic profile, and onset of puberty were evaluated (previously reported). After the feeding period, heifers were returned to the general herd at the South Dakota State University Dairy Research and Training Facility (SDSU-DRTF; Brookings, SD). Heifers were then managed under standard farm operating procedures.

Data and Measurement Collection

Data on reproductive performance which included the age at first artificial insemination (AI) service, number of AI services, and age at conception were collected from herd health records. Age at conception was based on when pregnancy was confirmed. Body growth measurements including BW, withers and hip heights, heart and paunch girth, body length, and hip width were measured one day 3 wk pre-partum (based on predicted calving dates) at approximately 4 h post-feeding. Body length was measured from the top point of the withers to the end of the ischium (Hoffman, 1997). Body condition score (BCS) was assessed by two individuals based on the scale described by Wildman et al. (1982) with 1=emaciated and 5=obese. Within 48 h post-calving, heifers were once again weighed and measured as previously described. Calf weights were also recorded. Because of the staggered dates that heifers were brought on to the prepubertal feeding trial due to heifer availability and the differing amounts of time that it took for heifers to conceive, calving took place over a fourteen month period from January 2015 to February 2016.

Lactation performance data was collected from January 2015 through June 2016. Data was collected from Dairy Herd Improvement Association (DHIA) records on each individual heifer for the first three months of lactation. Cows were milked twice daily at 0600 and 1800 h. For statistical analysis, data were analyzed by month of lactation because milk samples were collected for DHIA analysis randomly during each month from the farm, and calving dates differed for each heifer, the days in milk (DIM) at each test date were not equal for each heifer. Milk samples were analyzed for fat and protein concentration, as well as somatic cell count (SCC) at Heart of America DHIA Laboratory (Manhattan, KS). Mid-infrared spectroscopy (Bently 2000 Infrared Milk Analyzer, Bently Instruments, Chaska, MN; AOAC, 2002) was used for the analysis of fat and protein content. A flow cytometer laser (Somacount 500, Bentley Instruments: AOAC, 2002) was used for SCC. Energy corrected milk (ECM) was calculated as: ECM = [(0.327 × kg milk) + (12.95 × kg fat) (7.2 × kg protein)] (Orth, 1992).

Statistical Analysis

All data were analyzed using SAS version 9.4 (SAS Institute Inc., Cary, NC). The MIXED procedures of SAS were used for the analysis reproductive, BW, and frame measurement data. The model included treatment with block included as a random variable because samples were analyzed from a single time period. Body weight and frame measurements taken 3 wk prepartum were analyzed separately from BW and frame measurements taken at calving.

Lactation performance data were analyzed as a randomized complete block design with month as the repeated measure and the term heifer (block) as the subject using the PROC MIXED procedures of SAS (Littell et al., 2006). The model included treatment, month, and treatment × month interactions. Akaike's criterion was used to determine the most suitable covariance structure in repeated measures for each parameter. Covariance structures tested were compound symmetry, first-order autoregressive, Toeplitz, and unstructured. Compound symmetry resulted in the least absolute Akaike's values and was used for the final model. Significant differences among treatments were declared at $P \leq 0.05$ and tendencies were declared at $0.05 < P \leq 0.10$. Linear and quadratic effects of treatments were analyzed using orthogonal contrasts.

RESULTS AND DISCUSSION

Reproductive Performance

Reproductive data, as well as body weight and frame measurements 3 wk pre-partum and at parturition are presented in Table 2. According to standard farm protocols, heifers were first serviced off the first observable heat after reaching 13 months of age. If first service was unsuccessful they were then entered into a synchronization timed AI program. Age at first service tended to linearly decrease with increasing inclusion amount of DDGS. As previously reported heifers on the 50DG treatment tended to have increased concentrations of plasma cholesterol. This is of interest because cholesterol is a precursor to steroid hormones such as progesterone (Talavera et al., 1984). Additionally, a large percentage of heifers on the 50DG treatment were cycling at an earlier age. However, there were no differences in most reproductive parameters evaluated (Table 2). All treatments had similar ages at conception and number of services. However, heifers in the current experiment were only fed the experimental diets for 16 wk (6.5- 10.5 months of age) and further research is warranted to determine if there would be more of an impact if heifers were fed DDGS all the way through breeding age.

There were minimal difference in heifer body size or calf weight among treatments, demonstrating that prepubertal diets had minimal effect on post-trial performance. According to Hoffman (1997) Holstein heifers should be between 580 and 635 kg at calving. Heifers on the current experiment were within these guidelines. Reproductive and body size parameters were similar to those reported by Anderson et al., (2015).

Percent conception based upon artificial insemination service number is presented in Figure 1. Although not significant, heifers had approximately 40% conception on first service with 30DG heifers being numerically greater. Additional research may be warranted with larger numbers of animals to further understand the interaction of the increasing inclusion rate of DDGS and reproduction in more detail.

Lactation Performance

Lactation performance during the first three months of lactation is presented in Table 3. There was a treatment by wk interaction for SCC. The reason for this is unknown because there has not been a demonstrated interaction between feeding strategy or ADG on SCC. There were no differences in any of the other lactation parameters measured. During the prepubertal period, heifers had ADG of 0.91, 0.96, and 0.95 kg/d. This is greater than the recommended ADG of 0.8 kg/d to maximize lactation milk production (Zanton and Heinrichs, 2005). However, there were no differences in production among treatments in the current experiment. Anderson et al. (2015) demonstrated an increase in milk production for heifers limit-fed low- or high-fat DDGS compared to a control diet with similar ADG among treatments. However, the ADG was also greater than recommended (Anderson et al., 2015). This suggests that heifers fed DDGS were able to achieve similar or improved mammary parenchyma development. It also suggests that form of dietary energy (starch versus fat) may play a role in growth and development during the prepubertal period (Anderson et al., 2015). In the current experiment there appears to be less of an effect of inclusion amount of DDGS fed in replacement of forage during the prepubertal period on milk production.

CONCLUSIONS

In agreement with our hypothesis, limit-feeding diets containing increasing amount of DDGS at up to 50% of dietary dry matter during the prepubertal period tended to decreased age at first service while resulting comparable frame measurements at parturition. Heifers fed DDGS at 50% of diet dry matter also maintained lactation performance compared to heifers fed DDGS at 30 and 40% of diet dry matter. This indicates that heifers can be limit-fed increased amounts of DDGS during the prepubertal period without detrimental effects on post pubertal growth, reproduction, or lactation performance during the first three months of the first lactation. Overall, this research and the results from the growth performance and metabolic profile of these heifers during the feeding period demonstrates that DDGS can be incorporated into dairy heifer diets in order to decrease heifer feed costs to maintain growth performance, increase feed efficiency, without negative effects on subsequent reproductive or lactation performance.

EDUCATION, OUTREACH, AND PUBLICATIONS

Identify conferences, workshops, field days etc. at which project results were presented. Include number of farmers estimated to be present. List articles and/or manuscripts in which project results were published.

(Note: These are for the original project and continuation/additional funding as there is overlap in outputs)

Dissertation:

1. Angela K. Manthey. 2016. Ph.D. Dissertation: Growth performance, nutrient utilization and metabolic profiles of dairy heifers fed diets high in distillers grains with different forage to concentrate ratios. South Dakota State University, Brookings, SD. (Between the original

project funding and this project funding, MCR&PC contributed the funding for approximately 70% of the research contained in this dissertation.)

Abstracts:

1. Manthey, A. K., **J. L. Anderson**, and G. A. Perry. 2015. Growth Performance of dairy heifers fed reduced-fat distillers grains in replacement of forage in limit-fed rations. J. Dairy Sci. 98: Suppl. 2: 459 (Abstr. T415). (Joint Annual Meeting American Society of Animal Science and American Dairy Science Association)

2. Manthey, A. K., **J. L. Anderson**, G. A. Perry, and D. H. Keisler. 2015. Metabolic profile and onset of puberty in dairy heifers fed reduced-fat distillers grains in replacement of forage. J. Dairy Sci. 98: Suppl. 2: 735 (Abstr. W329). (Joint Annual Meeting American Society of Animal Science and American Dairy Science Association)

Manuscripts in Peer-Reviewed Journals:

1. Manthey, A.K., J. L. Anderson, and G.A. Perry. 2016. Feeding distillers dried grains in replacement of forage in limit-fed dairy heifer rations: Effects on growth performance, rumen fermentation, and total-tract digestibility of nutrients. J. Dairy Sci. *Accepted- In-press*. http://dx.doi.org/10.3168/jds.2015-10785.

2. Manthey, A. K., J. L. Anderson, G. A. Perry and D.H. Keisler. 2016. Feeding reduced-fat distillers dried grains in replacement of forage in limit-fed dairy heifer rations: Effects on metabolic profile and puberty. J. Dairy Sci. *Submitted- In Review.*

3. Manthey, A.K., J. L. Anderson, and G.A. Perry. 2016. Short Communication: Feeding distillers dried grains in replacement of forage in limit-fed dairy heifer rations: Effects on post-trial performance. J. Dairy Sci. *In final preparation*. (*Plan to submit in Aug 2016).*

SDSU Extension e-articles:

1. Angela Manthey and Jill Anderson. 12/1/2015. Reduced-Fat Distillers Grains: How much can we feed to growing dairy heifers? iGrow.org – Livestock – Dairy – Innovation/Research. http://igrow.org/livestock/dairy/reduced-fat-distillers-grains-how-much-can-we-feed-to-growing-dairy-heifers/#sthash.79hym4Pc.dpuf

Note – other igrow articles on metabolism, puberty, and post-trial results are currently being written and will be submitted to the SDSU extension service by the end of Aug 2016.

Radio interviews/spots:

1. Jill Anderson. MCGA Radio. Feeding DDGS to heifers. Aired 12/2014 on Linder Farm Network and Red River Farm Network. https://www.youtube.com/watch?v=elBUWida6qg&feature=youtu.be

2. Angela Manthey (Ph.D. Advisee). iGrow (SDSU Extension) Radio. Feeding reduced fat DDGS to growing dairy heifers. Aired 12/3/2015 on Dakota Farm Talk. http://podcast.sdstate.edu/groups/igrowradio/weblog/c6a65/Feeding_reduced_fat_DDGS_to_growing_dairy_heifers.html

3. Dairy Herd Management also had an article featuring this research by Jim Drickell, which received a mention on the Ag Day TV show.

Extension Workshops:

1. INVITED: Jill Anderson. Heifers Diets and DDGS feeding consideration. I-29 Dairy Consortium Workshop. Growing your best calves and heifers. January 5-8, 2015 in Orange City IA, Brookings SD, Fergus Fall MN, and Mandan ND.

2. ***Upcoming*** INVITED: Jill Anderson. Title: TBD. Topic: Feeding low cost diets, especially DDGS, to growing dairy heifers. University of Nebraska Extension Workshop, November 9-10, 2016 in Beatrice and Norfolk, NE.

REFERENCES

Anderson, J. L., K. F. Kalscheur, A. D. Garcia, and D. J. Schingoethe. 2015. Short Communication: Feeding fat from distillers dried grains with solubles to dairy heifers: III. Effects on post-trial reproductive and lactation performance. J. Dairy Sci. 98:5720-5725.

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Ettema, J. F., and J. E. Santos. 2004. Impact of age at calving on lactation, reproduction, health, and income in first-parity. Holsteins on commercial farms. J. Dairy Sci. 87:2730-2742.

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Meyer, M. J., A. V. Capuco, D. A. Ross, L. M. Lintault, and M. E. Van Amburgh. 2006. Development and nutritional regulation of the prepubertal heifer mammary gland: I. Parenchyma and fat pad mass and composition. J. Dairy Sci. 89:4289-4297.

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Talavera, F., C. S. Park, and G. L. Williams. 1985. Relationships among dietary lipid intake, serum cholesterol, and ovaria function in Holstein heifers. J. Anim. Sci. 60:1045-1051.

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Wildman, E. E., G. M. Jones, P. E. Wagner, R. L. Boman, H. F. Troutt Jr., and T. N. Lesch. 1982. A dairy cow body condition scoring system and its relationship to selected production characteristics. J. Dairy Sci. 65:495-501.

Zanton, G. I., and A. J. Heinrichs. 2005. Meta-analysis to assess effect of prepubertal average daily gain of Holstein heifers on first-lactation production. J. Dairy Sci. 88:3860-3867.

Zanton, G. I., and A. J. Heinrichs. 2009. Digestion and nitrogen utilization in dairy heifers limit-fed a low or high forage ration at four levels of nitrogen intake. J. Dairy Sci. 92:2078-2094.

Table 1. Ingredient and nutrient composition of treatment diets with increasing inclusion amounts of distillers dried grains with solubles (**DDGS**) in replacement of forage fed to growing replacement dairy heifers during the prepubertal growth phase

	Treatment[1]		
Item	30DG	40DG	50DG
Ingredient[2], % DM			
DDGS	30.0	40.0	50.0
Grass hay	68.5	58.5	48.5
Vitamin and mineral premix[3]	0.75	0.75	0.75
Limestone	0.30	0.30	0.30
Sodium bicarbonate	0.30	0.30	0.30
Salt	0.15	0.15	0.15
Nutrient, % of DM			
DM, % of diet	86.7	86.7	86.8
CP	16.8	16.8	16.8
Ether extract (diethyl)	5.17	5.17	5.17
Starch	2.38	2.38	2.38
ME, Mcal/kg	2.38	2.38	2.38
NE_G, Mcal/kg	2.89	2.89	2.89

[1]30% dietary inclusion rate of DDGS (**30DG**); 40% dietary inclusion rate of DDGS (**40DG**); 50% dietary inclusion rate of DDGS (**50DG**).

[2]Formulated using NRC, 2001.

[3]Contained: 2.2 g/kg of lasalocid, 14.5% Ca, 8.0% P, 21.0% NaCl, 2.5% Mg, 1.5% K, 2.0% S, 4,100 mg/kg Mn, 1,250 mg/kg Cu, 70 mg/kg Co, 70 mg/kg I, 53 mg/kg Se, 5,500 mg/kg Zn, 325 mg/kg Fe, 704,000 IU/kg Vitamin A, 140,800 IU/kg Vitamin D_3, and 5,280 IU/kg Vitamin E (Future Cow Supreme Premix B2000, Land O' Lakes, Inc., St. Paul, MN).

Table 2. Reproductive performance, body weight, and frame measures for heifers fed increasing amounts of distillers dried grains with solubles (**DDGS**) in replacement of forage during the prepubertal growth period

	Treatment[1]				*P-value*[2]		
Item	30DG	40DG	50DG	SEM	Trt	L	Q
Age at first service, d	411.5	413.6	399.0	5.13	0.09	0.08	0.19
Age at conception, d	412.6	413.3	434.8	25.8	0.51	0.31	0.59
AI service, no.	1.80	1.61	2.17	0.75	0.52	0.45	0.39
Predicted age at calving, d	697.7	681.4	711.9	24.35	0.34	0.51	0.19
Actual age at calving, d	698.2	682.9	715.2	25.1	0.34	0.44	0.20
Body measures, 3 wk prepartum							
BW, kg	681.3	667.1	693.7	18.8	0.57	0.64	0.34
Withers height, cm	149.2	148.6	150.2	1.36	0.38	0.54	0.21
Hip height, cm	150.3	149.4	150.9	0.92	0.48	0.65	0.26
Heart girth, cm	199.9	201.2	202.1	5.45	0.83	0.54	0.96
Paunch girth, cm	243.5	246.1	246.5	2.51	0.63	0.39	0.70
Body length, cm	154.6	154.6	154.0	1.14	0.90	0.69	0.82
Hip width, cm	55.8	55.9	56.3	0.60	0.82	0.55	0.84
BCS	3.29	3.32	3.33	0.074	0.73	0.44	0.89
Body measures, at parturition							
BW, kg	631.6	615.3	623.7	29.5	0.74	0.71	0.50
Withers height, cm	149.6	147.8	149.8	2.12	0.30	0.87	0.13
Hip height, cm	151.9	149.8	152.5	0.96	0.10	0.66	0.04
Heart girth, cm	201.5	200.3	201.3	5.83	0.94	0.96	0.73
Paunch girth, cm	237.2	238.0	234.0	2.59	0.50	0.39	0.43
Body length, cm	157.9	154.9	153.8	1.13	0.04	0.02	0.48
Hip width, cm	55.3	55.2	55.0	0.60	0.93	0.71	0.89
BCS	3.16	3.19	3.19	0.070	0.88	0.71	0.73
Calf BW, kg	39.2	40.4	39.3	2.77	0.78	0.95	0.48

[1]30% dietary inclusion rate of DDGS (**30DG**), 40% dietary inclusion rate of DDGS (**40DG**), 50% dietary inclusion rate of DDGS (**50DG**).
[2]Significance of effects for treatment (**Trt**), linear (**L**) and quadratic (**Q**) orthogonal contrasts.

Table 3. Milk production performance based on Dairy Herd Improvement Association (**DHIA**) records for heifers fed increasing amounts of distillers dried grains with solubles (**DDGS**) in replacement of forage during the prebubertal growth period

	Treatment[1]				*P-value*[2]				
Item	30DG	40DG	50DG	SEM	Trt	mo	Trt*mo	L	Q
Milk yield, kg	27.4	28.8	29.4	1.85	0.74	<0.01	0.30	0.46	0.84
ECM[3], kg	19.3	19.8	20.2	1.17	0.84	0.03	0.40	0.56	0.93
Fat, %	4.54	4.66	4.66	0.29	0.94	<0.01	0.61	0.76	0.85
Fat yield, kg/d	0.59	0.59	0.60	0.040	0.99	0.96	0.40	0.90	0.93
Protein, %	2.88	2.92	2.96	0.08	0.80	0.07	0.92	0.51	0.96
Protein yield, kg/d	0.36	0.38	0.39	0.024	0.65	<0.01	0.24	0.36	0.97
Somatic cells, × 10^3/mL	451.0	132.6	113.4	84.0	0.01	0.06	0.02	<0.01	0.12

[1]30% dietary inclusion rate of DDGS (**30DG**), 40% dietary inclusion rate of DDGS (**40DG**), 50% dietary inclusion rate of DDGS (**50DG**).

[2]Significance of effects for treatment (**Trt**), month (**mo**), treatment × month (**Trt × mo**), and linear (**L**) and quadratic (**Q**) orthogonal contrasts.

[3]ECM = [(0.327 × kg of milk) + (12.95 × kg of fat) + (7.2 × kg of protein)] (Orth, 1992).

Figure 1. Percent conception based on service number for heifers fed increasing amounts of distillers dried grains with solubles (**DDGS**) in replacement of forage during the prepubertal growth period