**Iowa State Beef Checkoff Research Program**
**Final Report**

## I. COVER PAGE

**TITLE OF PROJECT:**

Starch and digestible fiber-based supplementation impact on first calf heifer performance and nutrient mobilization through the production cycle.

**INVESTIGATORS:**

Iowa Beef Center, Iowa State University Extension and Outreach

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**Project timeline:**

| | |
|---|---|
| *Initiation:* | February 2023 |
| *Live animal initiation:* | February 2023 |
| *Live animal completion:* | February 2024 |
| *Completion:* | May 2024 |

**Budget:**

| | |
|---|---|
| *Awarded* | $ 26,084.00 |
| *Spent* | $ 20,958.30 |
| *Remaining funds* | $ 5,125.70 |

## II. NONTECHNICAL SUMMARY

A study at the ISU McNay Research Farm in south central Iowa observed 2-year-old heifers from their first parturition over the course of a production year. From calving through four weeks post-AI, heifers were allocated to one of three treatment groups: an unsupplemented control, a corn supplement group (CORN), or a gluten supplement group (GLU). Supplements were delivered through a Super SmartFeed™ feeder, from C-Lock Inc., which utilizes EID tags to provide a set amount of supplement to individual animals. Supplement levels (5.56 lbs for CORN and 6.12 lbs for GLU) were based on a hay sample analysis for the first month after calving, when hay made up the base diet and were adjusted (2.38 lbs for CORN and 2.95 lbs for GLU) when pasture became the primary forage source and hay feeding ceased. For the pasture supplement level, assumptions were made on the quality of the pasture.

Variables collected included carcass ultrasound measures (rib fat, ribeye area, and intramuscular fat) and body weight at five time points from about one month prior to the expected start of the 2023 calving season to about one month prior to the start of the 2024 calving season. The 2023 calf weaning weights were collected and the first two cycles of calving in 2024 were used to confirm pregnancy data.

The high nutritional demands of peak lactation caused females to lose weight and condition between calving and breeding season. Heifer numbers utilized in the study limited the statistical differences observed, but when observing numeric differences, unsupplemented heifers had the poorest condition at the time of synchronization. Supplementing first calf heifers improved conception to artificial insemination and the number of open heifers after the 65-day breeding season. Likewise, supplementation treatments averaged a 25-pound 205 adjusted weaning weight advantage compared to calves nursing unsupplemented dams. In addition to heifer and calf performance measures, cool season, unimproved fescue-based pasture samples were taken weekly during the supplementation period and analyzed for yield and quality. The results showed that pasture quality was overestimated and drought significantly restricted quantity.

Applying some simple math can help evaluate the supplement return on investment. To limit our example to just the corn-supplemented group, the weaning weight advantage was 18 lbs/calf. If we assume a calf price of $2.50/lb, that's about a $45 added value. On average, each heifer in the corn group consumed just shy of 5 bu of corn per heifer. At $6.23/bu, corn was $31/heifer for the supplementation period. In this scenario, the economics dictated that supplementation of first calf heifers from calving to breeding was economical, even without considering the next calf crop's advantage from CORN realizing fewer open heifers and more calves sired AI.

## III. TECHNICAL REPORT

### a. Impact

The nutritional demands of recovering from parturition, lactating and growing themselves is a stress on first calf heifers prior to the rebreeding season. Corn and corn co-products are readily available feedstuffs producers can utilize as supplements to assist these females in meeting nutritional demands, but performance expectations differ between supplements depending on the composition and how it is processed in the rumen. This study aimed to evaluate performance differences between unsupplemented heifers and heifers supplemented with corn or gluten from calving through the first month of the breeding season. The reproductive and weaning performance after the supplementation period can be used to compare the return on investment of the corn and gluten pellet supplements used in this study to help producers make more informed decisions when determining how to best fit the nutritional needs of the cowherd.

### b. Methods and Results

***Methods***

Fifty-five Angus first-calf heifers at the McNay Research Farm were allocated to one of three supplement treatment groups; corn (CORN; n=17), gluten pellets (GLU; n=18), or no supplement (CON; n=20). Rectal ultrasound was used for pregnancy diagnosis and estimation of calving date. Body weight, carcass ultrasound, body condition score and docility scores were taken approximately one month prior to the start of calving. Heifers were stratified into treatment groups based on Milk EPD, expected calving date, and initial measurements collected. Final treatment group summary statistics are reported in Table 1. By design, no significant differences ($p < 0.10$) exist between treatment group initial measures.

All heifers were managed on a common hay diet in a 48-acre calving paddock and managed as one group throughout the trial. Supplementation was provided through a mobile feeder (Super SmartFeed™, C-Lock Inc., Rapid City, SD) which uses EID tags to supply weighed supplement amounts. Supplementation began near the start of calving season (April 6) through about four weeks post artificial insemination (July 21). Supplementation amount was determined using hay sample analysis, expected pasture quality, and ration formulation software (BRaNDS, Iowa State University, Ames, IA). From April 6 to May 22, supplemented animals received up to 5.8 lbs/hd/d and 6.2 lbs/hd/d for CORN and GLU, respectively. Heifers were moved to fresh pastures and hay feeding ceased. From May 22, supplement levels were adjusted to 2.5 lbs/hd/d for CORN and 3.0 lbs/hd/d for GLU.

Body weight, carcass ultrasound data and body condition score were collected at five time points; about a month before calving season began (February), the start of breeding season (June), weaning (October), the start of third trimester (December), and about a month prior to the second calf (February) to get a full production cycle of data. Blood urea nitrogen (BUN) was taken at CIDR insert and removal in June. Pregnancy diagnosis data, and calving data from the first 42 days of the second calving season were analyzed. Heifers were artificially inseminated (AI) on 6/22/23 following a 7-day CIDR protocol and clean up bulls were turned out on 6/26/23. Calf weaning weights were adjusted to a 205-day weaning weight. A timeline for all live animal data collection is illustrated in Figure 1. Animal performance data were analyzed using R Statistical Software version 4.4.0.

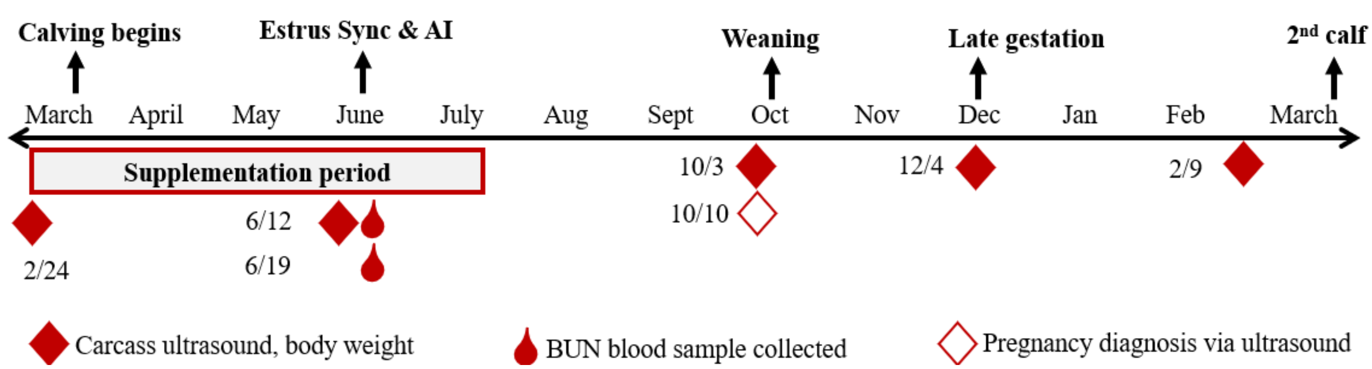
Pasture samples were taken at approximately weekly intervals during the supplementation period to retrospectively characterize true diet quality during the supplementation period. A forage square was used to collect five random samples in the pasture area cattle grazed. Samples were clipped to a height of one inch or less, and immediately put on ice and frozen for future analysis. Samples were weighed and dried to calculate yield. Replications from the same date were then composited by date and submitted to a commercial laboratory (Rock River Laboratory, Inc.) for NIR nutrient analysis. Grazing management was a slow rotation system, and more closely resembled a continuous grazing plan. Because of water infrastructure limitations, some paddocks were given access by opening the gate to allow cattle into multiple paddocks at once. This complicated sampling forage representative of what and where cattle were eating. Additionally, significant drought conditions limited grass growth over the entire sampling period. It is important to note that hay feeding continued until mid-May, and pasture yield was not sufficient for cattle to consume a pasture only diet until then.

**Table 1. Initial[1] treatment group averages ± Standard Deviation**

| | Corn supplement (CORN, n = 17) | | Gluten supplement (GLU, n = 18) | | Control (CON, n = 20) | |
|---|---|---|---|---|---|---|
| Heifer Age (days) | 685 | ±18 | 688 | ±17 | 681 | ±18 |
| First calving date | 4/03/23 | ±13 | 3/30/23 | ±14 | 3/31/23 | ±22 |
| Heifer Body Weight | 1079 | ±47 | 1096 | ±58 | 1076 | ±76 |
| Visual BCS | 5.3 | ±0.3 | 5.2 | ±0.3 | 5.3 | ±0.4 |
| Calculated BCS [2] | 4.8 | ±0.5 | 4.7 | ±0.9 | 4.6 | ±0.7 |
| Rib Fat Thickness | 0.22 | ±0.05 | 0.21 | ±0.09 | 0.20 ± | 0.07 |
| Ribeye Area | 9.5 | ±1.0 | 9.7 | ±1.1 | 9.8 | ±1.0 |
| Intramuscular Fat | 6.7 | ±1.3 | 6.5 | ±1.7 | 6.6 | ±2.0 |
| Docility Score | 1.3 | ±0.5 | 1.3 | ±0.4 | 1.1 | ±0.4 |
| MILK EPD | 24.8 | ±2.9 | 24.9 | ±3.3 | 24.0 | ±2.9 |

[1] Measures taken approximately 1 month before calving season began.
[2] Calculated BCS = (Rib fat thickness / Ribeye area) * 100) + 2.5

**Figure 1. Timeline of live animal data collection dates.**



## ***Results and Discussion***

*Animal Performance*

Key performance measures are reported in Table 2. Carcass ultrasound measures were used to calculate body condition scores where BCS = ((Ultrasound rib fat thickness, in / Ultrasound ribeye area, $in^2$) * 100) + 2.5. Body weight and calculated body condition changes over the production cycle are illustrated in Figure 2 and 3 respectfully.

**Table 2: Animal Performance Measures.**

| | Corn supplement (CORN, n = 17) | Gluten supplement (GLU, n = 18) | Control (CON, n = 20) | Pr (> F) |
|---|---|---|---|---|
| Empty[x] body weight change pre-calving to estrus synchronization, lbs | -99 | -101 | -119 | 0.34 |
| Calculated BCS at estrus synchronization[y] | 4.3 | 4.1 | 3.8 | 0.08 |
| Average Blood Urea Nitrogen[z] at CIDR insert and removal, mg/dl | 4.32[a] | 5.79[b] | 5.75[b] | < 0.01 |
| Adj. 205 day Weaning Weight, lbs | 523 | 538 | 505 | 0.24 |
| Open Heifers, % | 11.8 | 5.6 | 15.0 | 0.65 |
| AI or March-born calves, % | 60[a] | 24[ab] | 18[b] | 0.02 |
| First cycle born calves, % | 93 | 59 | 76 | 0.08 |

[ab] Values denoted with the same letter are not statistically different at the significance level of $P \leq 0.05$.

[x] Empty body weight accounts for fetal calf and applies a 4% shrink for gut fill.

[y] Calculated BCS = (Ultrasound rib fat thickness, in / Ultrasound ribeye area, $in^2$) * 100) + 2.5

[z] Normal blood urea nitrogen for milking beef cattle with a balanced ration is expected to be around 9 mg/dl

**Figure 2: Body weight treatment average over the production cycle**

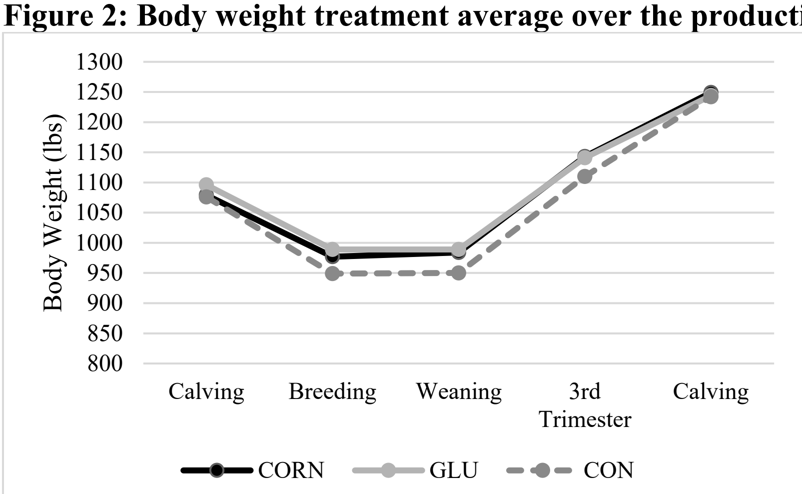
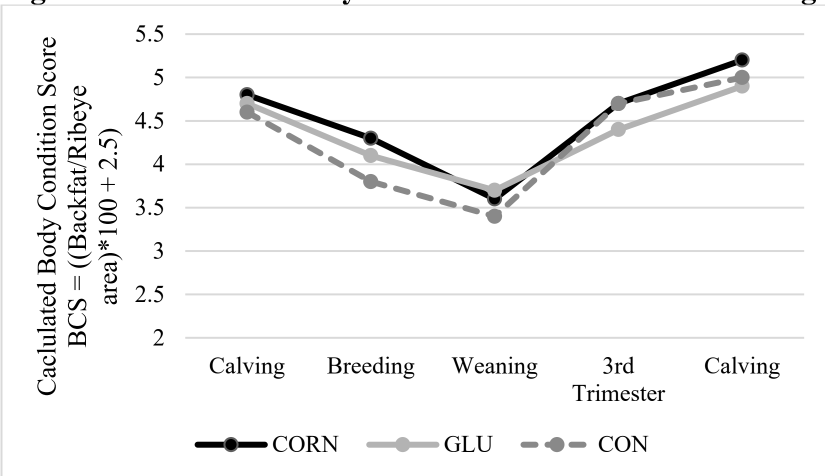


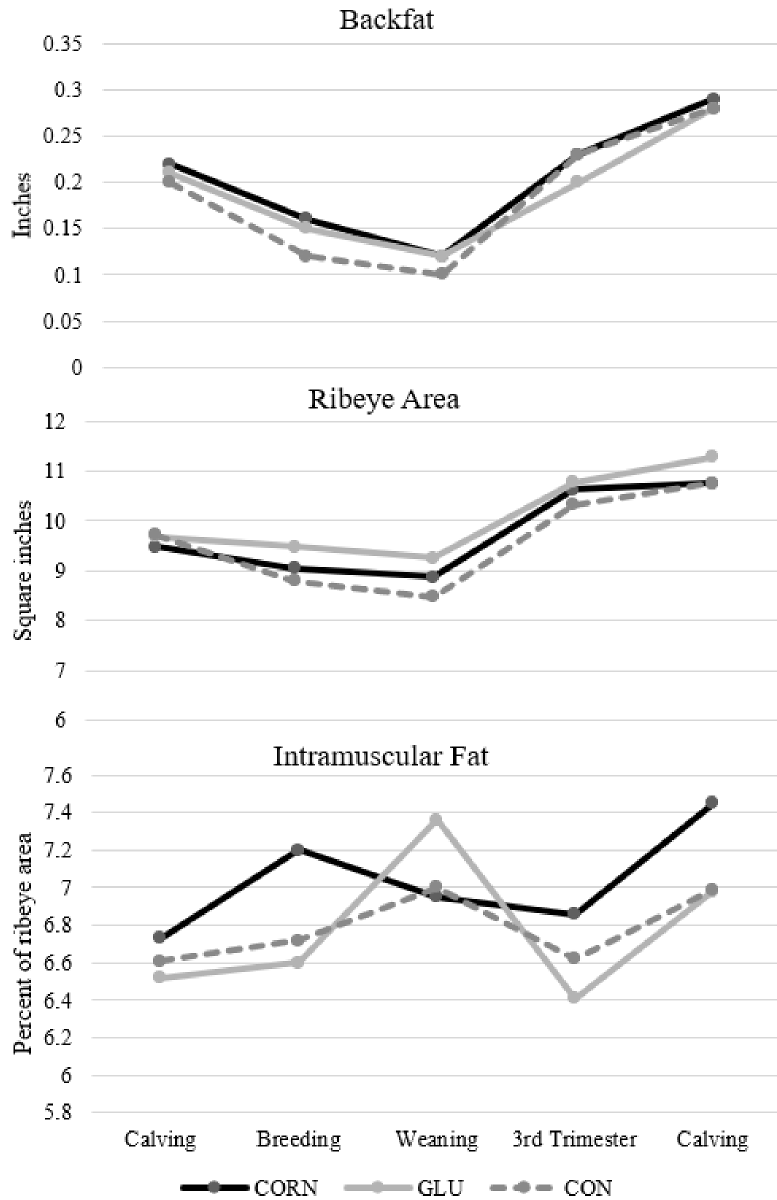
**Figure 3: Calculated body condition score treatment average over the production cycle**




At the time of synchronization, CON tended ($P = 0.07$) to be lower in BCS than CORN, with GLU intermediate. Table 2 shows strong significance ($P < 0.01$) in lower BUN levels in CORN at the time of synchronization and also a larger percentage of calves born before the expected AI due date for CORN ($P = 0.02$). Generally, this would be expected since a fermentable carbohydrate such as corn can effectively assist the rumen flora in utilizing any excess rumen available nitrogen and subsequently reduce circulating N in the blood stream. Likewise, data in the dairy industry shows reduced BUN would improve fertility and conception rates. However, the normal reason why BUN reduction improves fertility, such as modifying uterine pH, would not be a satisfactory explanation in this case. What was not expected, was the extremely low BUN levels realized by all treatments. These BUN levels were about ½ of what would be expected in an adequate lactating cow ration. At the onset on the trial, the fescue forage was anticipated to start near 20% crude protein (CP) at pasture turnout and then drop to 10 to 12% as the season progressed. The initial values were indeed near 20% CP, but the drop to 7% CP was quicker and more severe than anticipated. This created a protein deficiency and the heifers responded with mobilization of muscle.

Muscle mobilization is evidenced with decreased ribeye area (REA) (Figure 4) where the heifers receiving the corn gluten feed did not drop as severely as CON or CORN. Figure 4 illustrates how backfat (BF), REA and intramuscular fat (IMF) changed over the production cycle. Although no significant differences exist, numerical differences provide evidence that GLU retained more muscle, and CON lost the most BF over the supplementation period. For IMF, trends are harder to discuss because it is expressed as a percentage of ribeye area. One would expect an energy supplement like corn to help retain fat stores more effectively than a protein supplement or no supplement, and it does appear that CORN mobilized less marbling over the supplementation period from calving to breeding.

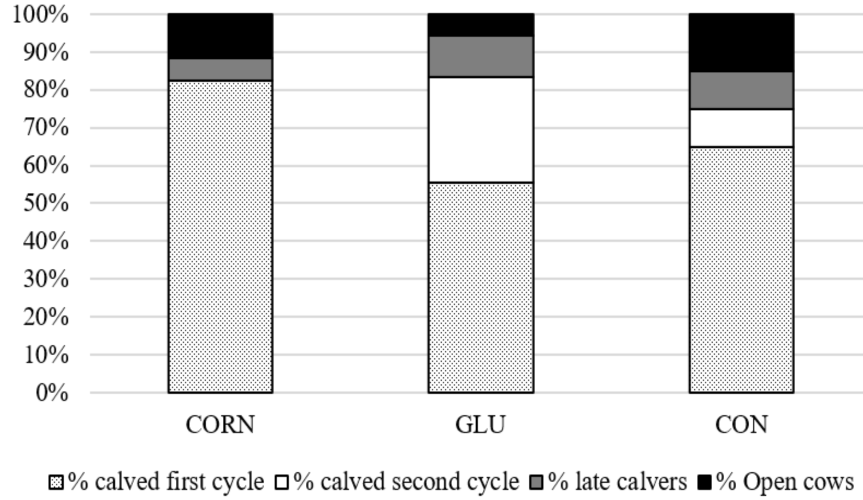
**Figure 4: Carcass ultrasound measures over the production cycle**




Retention of muscle likely allowed GLU to milk better as well. Protein becomes a limiting nutrient for milk production in a protein deficit since muscle protein cannot be drawn on as extensively as body fat would be for maintaining milk production from an energy standpoint. Therefore, when the corn gluten feed was supplied as a protein source, more milk production is likely. The 205-day calf weaning weights imply that this was the case. Weaning weight is an important performance indicator for cow-calf producers. Though not significant, the mean weaning weight of calves from GLU heifers was 33 lb. higher compared with CON, and calves from CORN were intermediate. This numerical trend suggests that the added dietary nutrients provided by both supplements allowed females to have a greater milk production in quantity and/or quality. Additional research needs to be done to better understand how supplementation impacts a beef cow's milk potential.

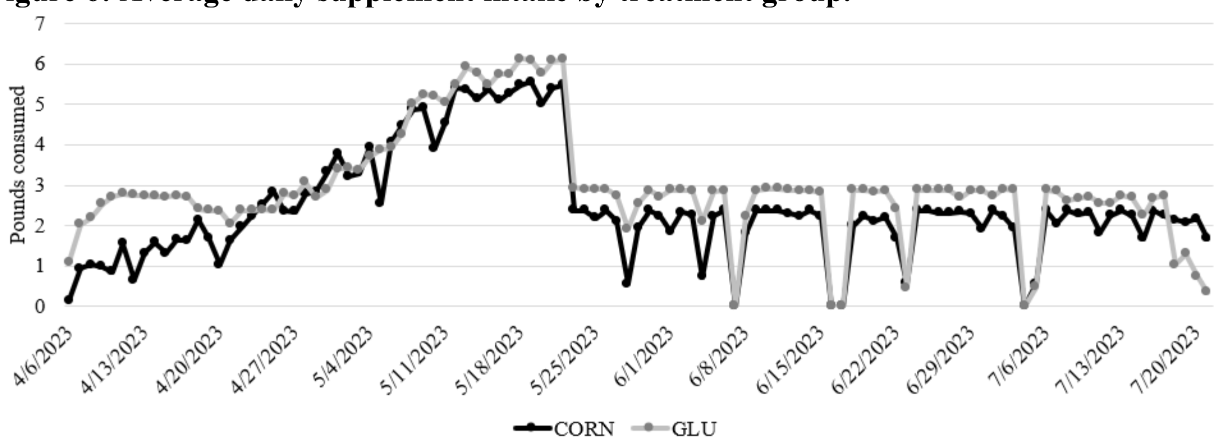
Another key performance indicator is reproductive success. Numerically, CON had the most open heifers. Although limited in numbers, this dataset reiterates the importance of meeting nutritional demands to optimize reproduction performance. Of calves born on or before the expected calving date for AI, CORN had more AI sired calves when compared with CON (60% vs 18% respectively; P = 0.02) and GLU was intermediate (24%). The advantage is not as apparent when considering calving distributions (Figure 5) as the advantage for CORN for calves born in the first 21 days would be considered a tendency (P = 0.08).

**Figure 5: Second-calf breeding and calving distribution.**




Over the 73-day supplementation period that all animals were receiving their final treatment group supplement, 15 percent of the animals in both the CORN and GLU group consumed less than 25% of their allotted supplement daily. The intake pattern during the supplementation period is illustrated in Figure 6. The inconsistency and behavioral differences make predicting results of typical bunk feeding situation challenging.

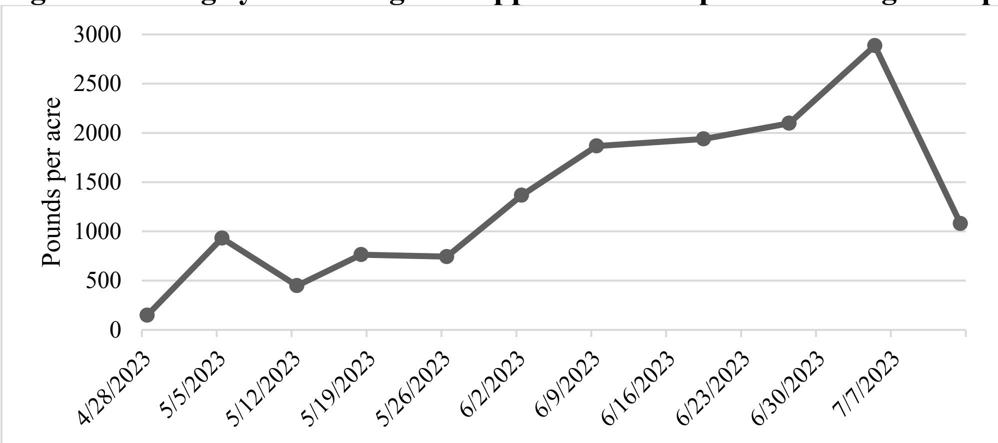
**Figure 6: Average daily supplement intake by treatment group.**




*Pasture quality*

Pasture samples were analyzed for quality after the supplementation period. As mentioned previously, pasture quality was lower than anticipated. Before discussing results, one should acknowledge the sampling protocol of clipping to one inch provides sampling consistency, but likely produces a lower quality sample than what cattle eat as they selectively graze. When sampling began, grass growth was slow, resulting in vegetative, tightly grazed, short forage that limited pasture intake. This resulted in hay providing the bulk of the diet in the early sampling timepoints. By the end of the sampling period, cool season grasses were in the reproductive stage and entering what is typically referred to as the summer slump. Pasture yield (Figure 7) at the end of the collection period was not limiting intake, but the quality of the forage declined.

**Figure 7: Forage yield during the supplementation period in the grazed paddock.**




Average quality measures for each sampling date are reported in Table 3. In general, protein, fiber and digestibility patterns followed the expected progression of grasses, with vegetative, young forage being higher quality (more protein, less fiber, more digestible) than the grass in later growth stages. One would expect non-fiber carbohydrates to decrease with plant maturity, and be elevated in drought years, but that expectation was not realized in this dataset.

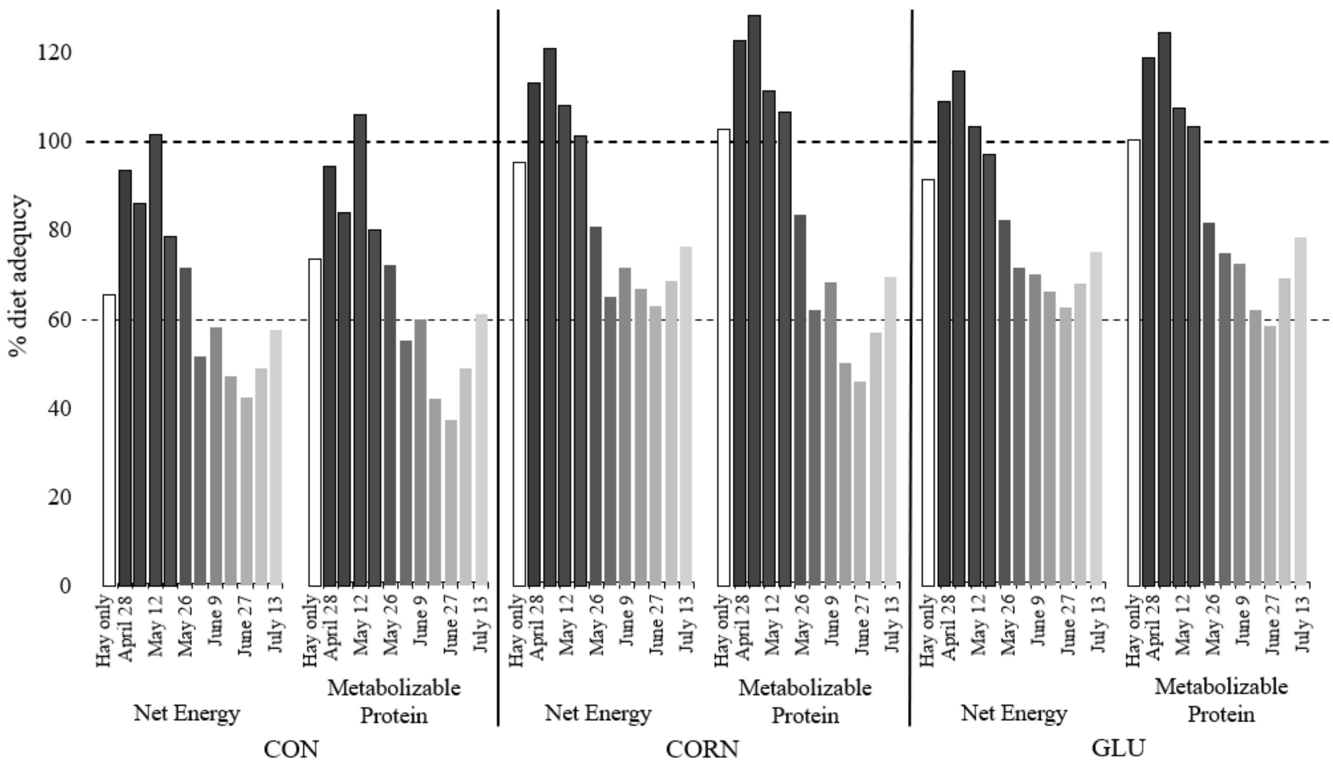
**Table 3. Forage quality results.**

| Sampling Date | DM (%) | CP (% DM) | ADF (% DM) | aNDF (% DM) | Lignin (% DM) | Sugar (WSC) (% DM) | Ash (% DM) | TTNDFd, (% NDF) | NFC (% DM) | TDN (% DM) |
|---|---|---|---|---|---|---|---|---|---|---|
| April 28 | 29.40 | 23.22 | 30.03 | 44.83 | 6.00 | 11.81 | 12.52 | 59.70 | 18.75 | 61.44 |
| May 5 | 27.18 | 20.06 | 28.44 | 44.64 | 5.00 | 12.24 | 10.09 | 57.07 | 24.24 | 64.75 |
| May 12 | 22.38 | 17.34 | 35.45 | 54.29 | 6.30 | 8.95 | 10.45 | 53.87 | 17.46 | 59.80 |
| May 18 | 26.05 | 16.98 | 36.19 | 55.36 | 6.35 | 9.18 | 12.36 | 52.45 | 14.59 | 56.10 |
| May 26 | 31.38 | 13.16 | 40.09 | 59.80 | 7.59 | 7.60 | 10.76 | 48.31 | 16.15 | 54.55 |
| June 2 | 30.35 | 10.82 | 43.24 | 64.85 | 8.97 | 6.60 | 9.21 | 42.24 | 15.64 | 48.97 |
| June 9 | 36.89 | 11.45 | 42.03 | 63.72 | 8.78 | 6.86 | 9.09 | 43.58 | 16.55 | 52.46 |
| June 19 | 46.47 | 8.22 | 41.45 | 60.79 | 8.73 | 10.31 | 7.34 | 38.85 | 22.90 | 50.97 |
| June 27 | 46.90 | 7.26 | 38.48 | 55.81 | 8.94 | 11.14 | 8.44 | 35.44 | 23.35 | 50.01 |
| July 5 | 40.30 | 9.20 | 41.14 | 59.09 | 8.68 | 9.77 | 8.73 | 37.50 | 22.50 | 52.26 |
| July 13 | 43.72 | 10.45 | 40.89 | 56.42 | 8.43 | 10.42 | 9.45 | 40.67 | 22.35 | 52.78 |

DM = Dry Matter; CP = Crude Protein; ADF = Acid Detergent Fiber; aNDF = Neutral Detergent Fiber; WSC = Water Soluble Carbohydrates; TTNDFd = Total Tract Neutral Detergent Fiber Digestibility; NFC = Non-fiber Carbohydrates; TDN = Total Digestible Nutrients

When the pasture quality is considered in conjunction with less than expected supplement consumption, it may explain why there were not greater differences between the supplemented and unsupplemented groups as hypothesized. Ultimately, in this study, all treatment groups experienced a negative energy balance rather than being supplemented to meet nutritional needs as anticipated. Because forage quality was lower than expected, weekly pasture quality measures were utilized in a ration formulation software program (BRaNDS, Iowa State University, Ames, IA) to demonstrate how the diet was meeting nutritional demands. Early lactation requirements for the first four weeks of grazed pasture were assumed and mid lactation requirements for week 5 through 11. Additionally, the supplement levels for each treatment group were adjusted for when hay feeding ceased, and pounds supplemented decreased. Figure 8 illustrates this by showing the percent of the dietary needs met for net energy and metabolizable protein for each treatment group over the supplementation period.

**Figure 8: Ration formulation software projected diet adequacy.**
*Does not account for pasture yield limitations on intake. From 4/28 thru 5/18, early lactation requirements and 5.8 lbs/hd/d for CORN and 6.2 lbs/hd/d for GLU assumed. From 5/26 thru 7/13, mid lactation requirements, 2.5 lbs/hd/d for CORN and 3.0 lbs/hd/d for GLU assumed.




It is important to recognize that this period is when the highest nutritional requirements of a cow's life are realized. Although pasture quality was near 100% of dietary needs early in the growing season, this was early, short forage growth and quantity was limiting until mid-May. Before that point, hay still made up a significant portion of the diet. Weight and body condition losses from calving to weaning emphasize the insufficiency of the pasture quality to meet or exceed requirements. As expected, the gluten supplement provides the most metabolizable protein. Although this pasture quality is lower than anticipated, it still emphasizes the importance of occasionally testing the forage base in order to best plan a supplementation program.

*Economic analysis*
Based on supplement price when fed and the actual amount of supplement consumed, CORN and GLU calves realized an approximately $15 advantage over CON calves if utilizing adjusted weaning weights to figure the return on investment for each supplement (Table 4). It is difficult

to estimate economic return on investment based on this single trial because heifers did not consume the full amount allotted to them, which may have impacted the results of this study. This economic analysis did not account for the potential impacts on the second calf performance, economic loss due to open heifers, and realized genetic potential from more AI sired calves.

**Table 4: Economic comparison of supplement program.**

| | Supplement cost/heifer using feed disappearance in trial[y] | Weaning weight advantage | Price advantage per calf [z] | Return per calf |
|---|---|---|---|---|
| CON | $0.00 | 0 lbs | $0 .00 | $0.00 |
| CORN[w] | $29.18 | 18 lbs | $45.00 | $15.82 |
| GLU[x] | $67.29 | 33 lbs | $82.50 | $15.21 |

[w] Corn sourced on farm. Price assumed = $6.23/bushel (IDALS reported Iowa State Average for May 2023)
[x] Gluten supplement was a bagged pellet from a local coop. Price in this study was $427/ton
[y] CORN consumed an average of 262 lbs of corn/heifer during the trial. GLU consumed 315 lbs of gluten pellets/heifer
[z] Assumed calf price is $2.50/lb

### c. Conclusions

Corn and corn co-product supplementation during phases of peak nutritional demands had positive impacts on first-calf heifer performance including increased weaning weights and conception rates. Smaller performance differences were realized in this study than hypothesized as all groups were experiencing a nutrient deficit. When nutritional requirements are not met, weight and body condition loss are expected and were realized, ultimately impacting reproductive performance.

It is important to consider how nutrient requirements fluctuate during the production cycle, and meeting these needs during peak nutritional demands is a challenge, even during the primary growing season. All groups were able to increase body condition, weight and carcass measures after weaning and prior to the next calving season, however the number of open and late calving heifers in the second pregnancy is a significant cost to operation. Considering the increase in weaning weight performance and associated feed cost with supplementation, there was a positive return on investment realized when supplementing first calf heifers going into the second breeding season.

### d. Unexpected Problems or Outcomes

- The Smartfeeder required parts replacements when the trial began. It took the C-Lock company time and sending a technician to the farm to identify the problem. Due to the hardware malfunctions, the planned acclimation period in March did not occur and heifers that had calved began treatments on April 6. As of April 27, only 10 of the 31 heifers with access to a supplement had consumed feed. This is likely due to the lack of a training period. A decision was made to allow all heifers access to supplement, including the unsupplemented control group, for the week of April 27 and re-assign treatment groups. Ultimately, 20 heifers never consumed feed and were assigned to the control group. To maintain treatment groups, three of the control group moved to the corn supplement, four of the control group moved to the gluten, and four from each the corn and gluten supplement groups did not consume feed and were placed in the control. Two heifers were removed from the trial following calf death loss in the spring.

- Heifers were inconsistent in supplement intake. Some of this can be explained by new paddock access and expected behavior patterns.
- A racoon entered gluten side of the feeder at the end of the trial and impacted ~4 days of data.
- Lab prices increased for both analyzing forages and carcass ultrasound images.

**e. Completed and Planned Publications, Presentations, and Outreach Media**

i. Presented mid-study data at McNay Research Farm field day in August 2023
ii. ISU McNay Research Farm Report – Submission on May 25th, published in the summer.
    1. Two reports submitted. One on heifer performance, another on pasture quality.
iii. BEEF digital magazine article, June issue
iv. ISU Animal Industry Report – not yet submitted.
v. Iowa Beef Center Growing Beef Newsletter (July issue)
vi. Results will be utilized in Iowa Beef Center extension programming efforts and presented in applicable field days

**f. Personnel Support**

*Beth Reynolds* committed 0.03 FTE of her time on the project ($2,392.96).
*Erika Lundy-Woolfolk* committed 0.03 FTE of her time on the project ($2,780.17).
*Garland Dahlke* committed 0.02 FTE of his time on the project ($2,535.80).
*Patrick Wall* committed 0.035 FTE of his time on the project ($3,510.95).
*An undergraduate student* dedicated approximately 55 hours of time on the project ($836.80).

**g. Budget**

| | Budgeted | Spent | Remaining |
|---|---|---|---|
| **Employee salary & benefits** | $ 11,318 | $ 12,056.68 | $ (738.68) |
| **Travel** | $ 2,391 | $ 1,200.51 | $ 1,190.49 |
| **Materials/Supplies** | $ 6,500 | $ 2,448.11 | $ 4,051.89 |
| **Professional Services** | $ 2,500 | $ 1,728.00 | $ 772.00 |
| **ISU McNay Research Farm user fees** | $ 3,375 | $ 3,525.00 | $ (150.00) |
| **Total** | $ 26,084 | $ 20,958.30 | $ 5,125.70 |

**h. Acknowledgements**

The project investigators would like to recognize farm staff in their efforts throughout the year in order to make this project possible. Additionally, Randie Culbertson, graduate student Sarah Phelps, and Christopher Clark helped collect data.