



2025

ALABAMA LIVESTOCK  
RESEARCH  
REPORT

*College of Agriculture*  
*Department of Animal Sciences*



## *Welcome*

The livestock industry remains a foundation of Alabama's agricultural economy, supporting rural communities, creating jobs, and providing high-quality animal protein for a growing population. Cattle are produced in every county in the state and represent an industry valued at more than \$2.5 billion annually. Alongside beef production, Alabama's broader animal agriculture sector, including poultry, pork, dairy, goats, and hay production, plays a vital role in sustaining the state's agricultural landscape. Recent assessments estimate that Alabama's food, fiber, forestry, and green industries contribute \$77.3 billion to the state's economy and support more than 273,000 jobs, accounting for nearly 10% of Alabama's workforce.

As global demand for animal protein continues to increase, livestock producers face evolving challenges related to efficiency, sustainability, environmental stewardship, and animal health. Addressing these challenges requires innovative research, strong partnerships, and a commitment to translating science into practical solutions for producers. The Department of Animal Sciences at Auburn University remains dedicated to advancing this mission through collaborative research and extension programs that support the livestock industry across Alabama.

The projects featured in this year's report highlight the diversity and impact of our research programs. From studies evaluating nutritional strategies to investigations of grazing systems that incorporate warm-season forbs, our researchers are working to improve animal performance while enhancing the sustainability of pasture-based production systems. Other efforts focus on reproductive biology and developmental programming, exploring how maternal nutrition and reproductive technologies influence early embryonic development and long-term animal performance. In addition, extension-focused research included in this report examines how educational programs can better reach and serve Alabama's livestock and equine communities.


We are pleased to present the fourth edition of the Alabama Livestock Research Report, which showcases research conducted by faculty, staff, and students in the Auburn University Department of Animal Sciences and our affiliated research and extension centers. Within these pages, you will find examples of how science, innovation, and collaboration are helping address real-world challenges faced by livestock producers throughout the state.

We are grateful to the many producers, industry partners, commodity groups, and funding agencies who make this work possible. Most importantly, we thank the faculty, staff, and students whose dedication and curiosity drive the research and outreach efforts highlighted in this report. Thank you for your continued support of Auburn University's Department of Animal Sciences and our shared commitment to strengthening Alabama's livestock industry.

We invite you to engage with this work, ask questions, share ideas, and join us as we continue to serve Alabama's livestock industry through research, education, and innovation.

**This is our work.**

Sincerely,



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# Performance and Digestion of Whole Cottonseed Offered Either Ad Libitum or Under Restriction to Beef Cows Nursing Calves

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## TAKE HOME MESSAGE

Whole cottonseed (WCS) provides a unique opportunity to utilize a byproduct of the cotton industry as a widely available, nutritious, and cost-effective feed option for beef cattle. The objective of this study was to determine appropriate WCS supplementation levels and digestibility when supplemented in bermudagrass hay diets. This study determined that beef cows supplemented with WCS had an increased dry matter intake (DMI), indicating increased performance, as well as unimpaired digestibility from the inclusion of high-fat feedstuff.

## SUMMARY

This research aimed to provide updated Extension recommendations on the inclusion of WCS in beef cattle diets following the genetic improvement of cotton and nutritional value changes of WCS since the original feeding recommendations. Cows offered WCS ad libitum consumed the greatest amount of WCS ( $P < 0.01$ ; 12.3 lb/day), followed those offered a fat-limited intake (7.5 lb/day) and those limited to a percent of DMI (2.6 lb/day). However, total daily intake was greatest under ad libitum (29.1 lb/day) and fat-limited (28.9 lb/day) offering and least in the control (21.8 lb/day), with DMI intermediate (25.4 lb/day;  $P < 0.01$ ). There was no effect of treatment on milk production ( $P = 0.57$ ) or calf body weight (BW;  $P = 0.82$ ). These findings suggest that beef cows nursing calves can consume WCS at near ad libitum levels without negative effects, though this may not always align with economic production goals.

## 1. INTRODUCTION

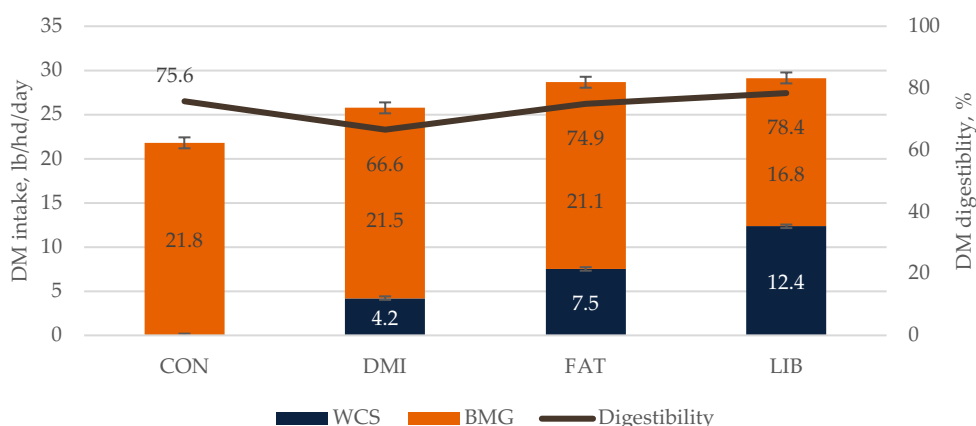
In the southeastern United States, whole cottonseed (WCS) is a widely available, nutritious, and cost-effective feed option for beef cattle. According to NRC (2016), WCS consists of about 52% neutral detergent fiber (NDF), 24% crude protein (CP), and 18% crude fat. Feeding guidelines for WCS in beef cattle diets were originally developed in the 1980s and based on the seed quality at that time. However, recent research has shown that changes in cottonseed varieties have altered its nutritional composition in the Southeast (Rigney et al., 2024). Considering these industry shifts, **the objective of this study was to investigate the digestibility of WCS and determine appropriate WCS supplementation levels in beef cow diets.**

## 2. PROCEDURES

This experiment was conducted at the Auburn University Stanley P. Wilson Beef Teaching Center Beef Cattle Evaluation Unit, following a generalized complete block design with two feeding pens (blocks), each containing eight cow-calf pairs. These pairs were randomly assigned to one of four feeding treatments: a control group receiving only bermudagrass (BMG) hay (CON); BMG supplemented with WCS at 15% of targeted dry matter intake (DMI); BMG supplemented with WCS to reach a crude fat intake of 4% dry matter (FAT); and BMG supplemented with WCS on an ad libitum basis (LIB). The experiment consisted of two 35-day periods, each made up of a 28-day adaptation phase and a 7-day collection phase. During the collection phase, cows were fed a 10-g TiO<sub>2</sub> bolus every day and Cr-mordanted cottonseed on day 1 and 5 to measure digestibility and seed passage rate, respectively. Feed and refusals were collected daily throughout the experiment, and fecal samples were collected during each 7-day collection phase.

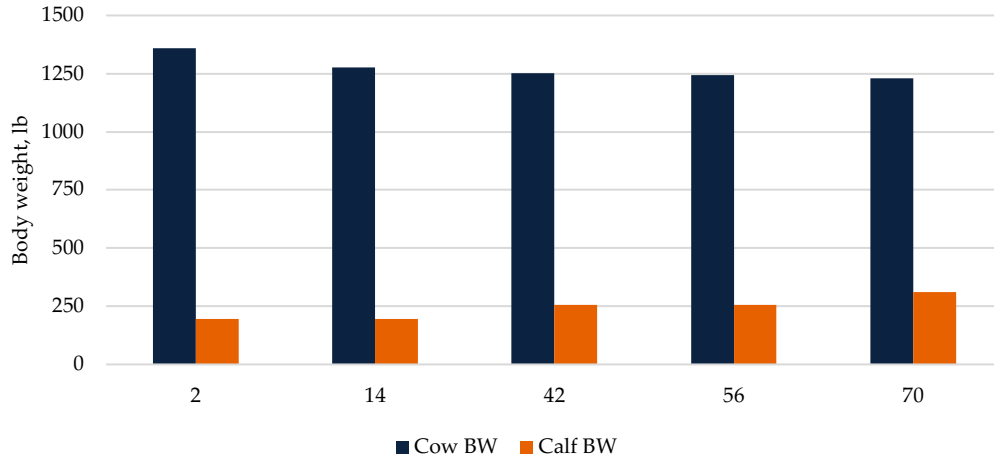
## 3. RESULTS & DISCUSSION

Inclusion of WCS, particularly in the FAT and LIB treatments, stimulated total DMI ( $P < 0.01$ ), while DM digestibility remained unaffected ( $P = 0.10$ ; Figure 1). This is indicative of a high energy diet with no impaired digestibility. Intake was 35% greater in the FAT (28.7 lb/hd/day) and LIB (29.2 lb/hd/day) diets than in the CON (21.8 lb/hd/day) diet. This increase, along with the unaffected digestibility, indicated that the cows in the FAT and LIB diets received increased total digestible nutrient supply.



**Figure 1.** Dry matter (DM) intake and digestibility of whole cottonseed (WCS) and bermudagrass (BMG) hay from cows either consuming BMG hay (CON) or supplemented with WCS at 15% of DM intake (DMI), 4% fat intake (FAT), or ad libitum consumption (LIB).

After decreasing post-peak lactation, cow body weight remained constant throughout the study ( $P < 0.01$ ; Figure 2). While there was no effect of treatment ( $P = 0.68$ ), calves gained weight throughout the study ( $P < 0.01$ ). Similarly, there was no difference in milk production among treatments ( $P = 0.57$ ; data not shown).



**Figure 2.** Cow and calf body weight (BW) from an experiment in which cows either consumed bermudagrass hay (CON) or were supplemented with WCS at 15% of DM intake (DMI), 4% fat intake (FAT), or ad libitum consumption (LIB).

### Acknowledgments

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### Funding

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# Inclusion of Whole Cottonseed in the Diets of Backgrounding and Finishing Cattle: A Backgrounding Summary

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## TAKE HOME MESSAGE

Whole cottonseed (WCS) is a byproduct of row crop production known for its high energy and protein concentrations. However, its incorporation into beef production systems has often been limited to the cow-calf phase of production or at low-level inclusion in the stocker phase. The purpose of this experiment was to evaluate the effect of WCS inclusion in the consecutive stockering and finishing phases of production on animal performance. Forty-eight steers were used in an 84-day stockering experiment to address this question. Supplementation with WCS resulted in increased average daily gain, meaning WCS may be a viable supplemental feedstuff for steers grazing warm-season pastures.

## SUMMARY

Whole cottonseed is a valuable resource in beef cattle production, but it may not be currently used to its full potential. This experiment was conducted as completely randomized design with a split-plot restriction on randomization. In the whole plot, twelve replicate pastures were stocked with four steers for an 84-day stocker/backgrounding experiment. Pastures were then randomly allocated to one of three treatments: an unsupplemented control (SUPP-C), daily supplementation of WCS at 0.5% BW (SUPP-L), or daily supplementation with WCS at 1.0% BW (SUPP-H). By design, there was no difference ( $P = 0.48$ ) in body weight (BW) among treatments at the initiation of stocking. There was an effect ( $P = 0.01$ ) of supplement, however, on average daily gain (ADG). Average daily gain was greatest ( $P < 0.05$ ) from SUPP-H and least from SUPP-C, with SUPP-L intermediate. Results are interpreted to mean that WCS may effectively be used as a supplemental feedstuff for steers grazing warm-season pastures.

## 1. INTRODUCTION

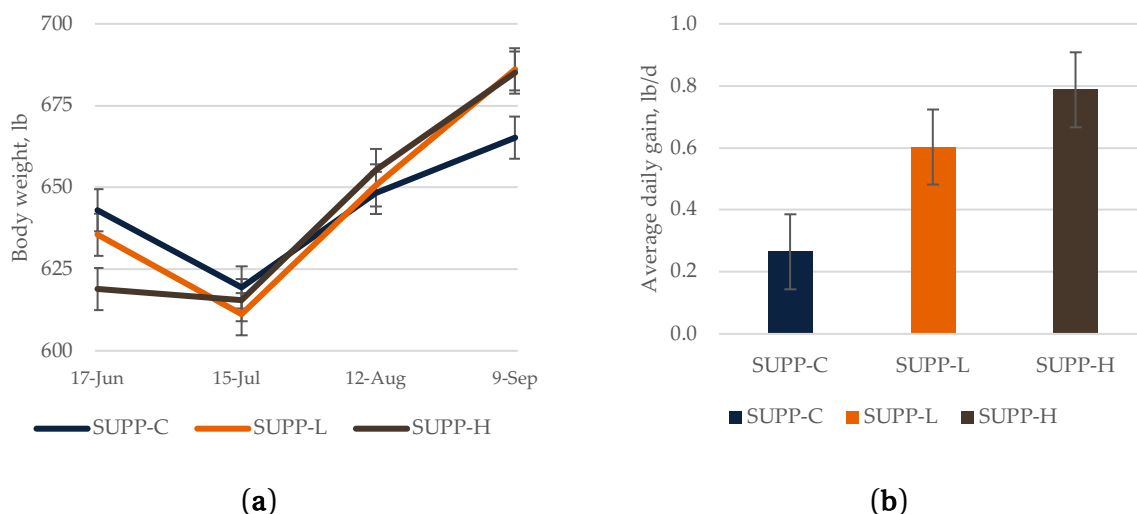
Whole cottonseed (WCS) is a secondary byproduct of row crop production known for its high protein and fat concentrations. An increase in the production of cotton in the southwestern area of the United States has increased the availability of cotton byproducts (Warner et al., 2020). As feed costs are the leading expense in beef cattle production (Ahola and Hill, 2012), understanding how best to incorporate WCS into multiple phases of the production cycle could improve overall efficiency of the system. Thus, **the objective of this experiment was to evaluate the effect of WCS incorporation in both the stockering/backgrounding phase and the finishing phase on animal performance.**

## 2. PROCEDURES

This study was conducted at the E. V. Smith Research and Extension Center Beef Unit in a completely randomized design with a split-plot restriction on randomization. In the whole plot, twelve replicate pastures were stocked with four steers for an 84-day stocker/backgrounding experiment. Pastures were then randomly allocated to one of three treatments: an unsupplemented control (SUPP-C), daily supplementation of WCS at 0.5% BW (SUPP-L), or daily supplementation with WCS at 1.0% BW (SUPP-H). Forage samples were collected every 14 days throughout the stockering period to assess forage allowance and nutritive value. Steers were weighed every 28 days, and blood was collected for assessment of energy and protein status.

## 3. RESULTS & DISCUSSION

By design, there was no difference ( $P = 0.48$ ) in body weight (BW) among treatments at the initiation of stocking. There was, however, an interaction ( $P < 0.01$ ) of treatment and date on BW across the stocking period (Figure 1a). By 84 days of stocking, steers allocated to SUPP-C had a lesser ( $P < 0.05$ ) BW than those allocated to SUPP-L or SUPP-H. This resulted in average daily gain (ADG) being greatest ( $P < 0.05$ ) from SUPP-H and least from SUPP-C, with SUPP-L intermediate.



**Figure 1.** (a) Body weight and (b) average daily gain from steers grazing signalgrass without supplemental feed (SUPP-C) or supplemented with 0.5% (SUPP-L) or 1.0% BW (SUPP-H) with whole cottonseed.

## Funding

This research was funded by the Cotton Incorporated, grant number 24-094.

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- Warner, A. L., P. A. Beck, A. P. Foote, K. N. Pierce, C. A. Robison, D. S. Hubbell, III, and B. K. Wilson. 2020. Effects of utilizing cotton byproducts in a finishing diet on beef cattle performance, carcass traits, fecal characteristics, and plasma metabolites. *J. Anim. Sci.* 98: skaa038. doi: 10.1093/jas/skaa038.

# Fecal Degradation and Nutrient Transfer to Soil from Steers Supplemented with Warm-Season Forbs

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## TAKE HOME MESSAGE

Beef cattle in grazing systems redistribute nutrients from their intake back into the soil. Understanding the nutrient cycling from livestock feces is important for sustainable pasture management. The objective of this study was to assess the rate of dry matter (DM), nitrogen (N), phosphorus (P), and potassium (K) loss from feces over time from steers supplemented with warm-season forbs. Our study determined that soil N, P, and K increase in the short-term, but more management is required for sustained elevated levels.

## SUMMARY

This research aimed to provide insight on how livestock, particularly beef cattle, can be utilized to redistribute nutrients from their feed into the soil. These findings may offer insight on how soil fertility can be impacted in the short-term by the fecal material of beef cattle. Fecal pats exhibited a numerical, but non-significant, decrease in remaining DM at 112 DAA ( $P = 0.13$ ; 76.9%). Soil organic matter (OM) demonstrated a pulse at 84 DAA at both the 0 – 2.5 in (4.6%) and 2.5 – 5 in (1.5%) depths ( $P = 0.04$ ). Soil N also showed a pulse at 56 DAA ( $P = 0.04$ ) at 0 – 2.5 in (6.8 lb/ac) and 2.5 – 10 in (2.2 lb/ac), with a concurrent pulse in soil P ( $P = 0.04$ ) at 0 – 2.5 in (73.1 lb/ac) and 2.5 – 5 in (30.6 lb/ac). Soil K increased at 24 DAA (260.4 lb/ac;  $P < 0.01$ ) before decreasing slightly by 112 DAA (213.5 lb/acre). There was no effect of dietary treatment on OM ( $P = 0.66$ ), N ( $P = 0.48$ ), P ( $P = 0.63$ ), or K ( $P = 0.45$ ). Collectively, these results suggest that diet composition did not influence nutrient transfer into soil and that OM, N, and P released from fecal pats likely moved downward through the soil profile. Therefore, potential fertilization benefit of supplemental feed ingredients may be more dependent on timing and grazing management than diet composition itself.

## 1. INTRODUCTION

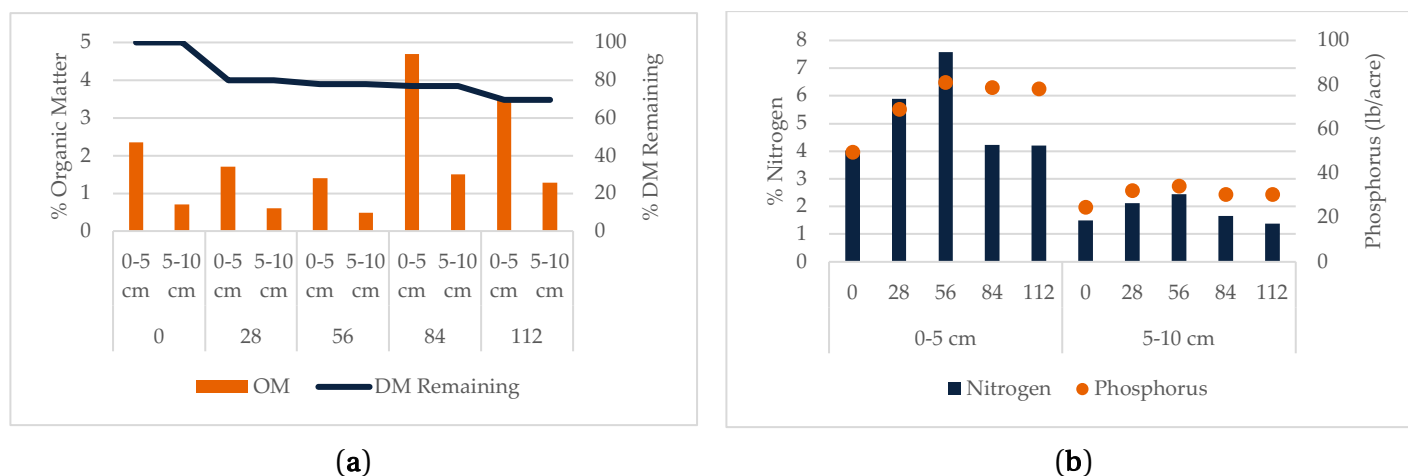
Southeastern soils, particularly Ultisols, present a challenge for farmers and ranchers due to their typically low fertility. While precipitation is relatively abundant in the Southeast, excessive weathering has left soil in this region relatively low in N, P, and K. Therefore, effective nutrient management is crucial in maintaining the fertility of pastureland and the development of improved forage systems. One method of soil nutrient management is “feedthrough fertilization” which uses livestock to redistribute nutrients from their feed into the soil profile. **The objective of this study was to assess the rate of DM and nutrient transfer from feces to soil from steers consuming warm-season grass and supplemented with forbs.**

## 2. PROCEDURES

Our study was conducted at the Auburn University Stanley P. Wilson Beef Teaching Center. Fecal material was obtained from a preceding metabolism study evaluating warm-season forb inclusion in steer diets. In this preceding study, four steers were fed a basal diet of bahiagrass hay and supplemented with either lablab, soybean, or sunn hemp hay across four periods. The nutrient cycling experiment was implemented using a randomized complete block design. Each steer (row) by period (column) combination from the metabolism study was assigned to five 10.8-ft<sup>2</sup> plots within three blocks. Plots were treated with 1.1 lb of feces (wet basis) and evaluated across five days-after-application (DAA) intervals: 0, 28, 56, 84, and 112 days. On the fourth day of each in vivo collection period, bulked fecal material was applied to field plots as 7.9-in diameter pats (Dillard et al., 2015). At each DAA, undegraded feces were collected, dried at 122°F, and ground for laboratory analysis. Soil samples were collected to a 5-in depth and subdivided into 0 - 2.5 and 2.5 - 5 in layers.

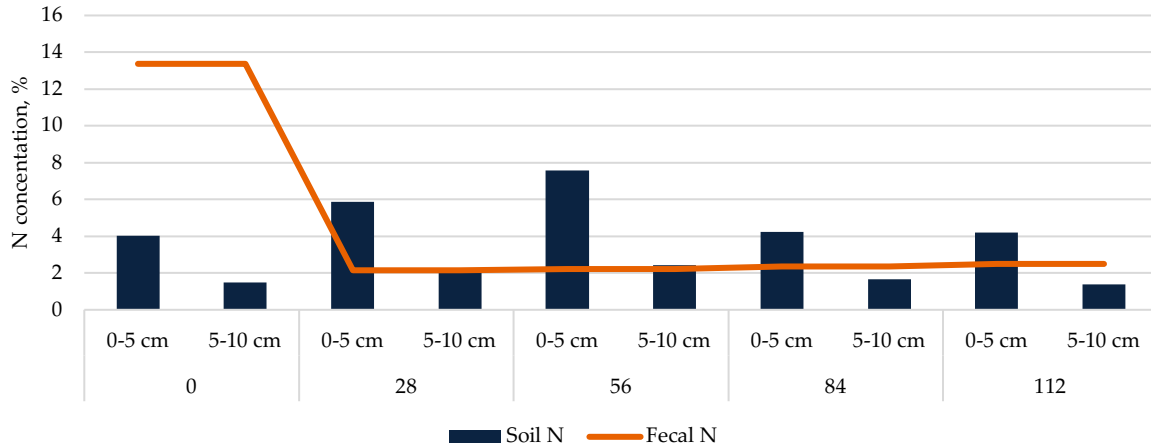
## 3. RESULTS & DISCUSSION

Soil OM peaked at both depths at 84 DAA before slowly declining ( $P = 0.02$ ; Figure 1a). Additionally, soil N ( $P = 0.04$ ) and P ( $P = 0.04$ ) both peaked at 56 DAA at both depths (Figure 1b). Soil N began to decrease after 56 days; however, soil P remained constant through 112 DAA. The loss of soil N is likely due to movement through the soil profile while the loss of soil K can be attributed to the poor cation exchange capacity of Ultisols. No relationship was found between treatment and soil nutrients ( $P > 0.05$ ).



**Figure 1.** Soil (a) dry matter and organic matter and (b) nitrogen and phosphorus from a nutrient cycling experiment evaluating warm-season forb inclusion in the diet of beef cattle.

While the warm-season leguminous forbs selected were relatively high in N, the target inclusion rate of 30% was not reached in any of the diets. The achieved inclusion rate for each diet was approx. 5%. This, along with urinary N loss, likely accounts for the lack of difference between diets. Fecal N was also analyzed and compared with soil N (Figure 2). Fecal nitrogen had an immediate, sharp decrease from 0 DAA to 28 DAA where it remained the same through 112 DAA ( $P < 0.01$ ).



**Figure 2.** Soil and fecal nitrogen from a nutrient cycling experiment evaluating warm-season forb inclusion in the diet of beef cattle.

**Acknowledgments**

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**Funding**

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# Determining Digestive and Metabolic Parameters in Beef Cattle Exposed to Grass-Forb Systems Including Naturally Occurring Plant Secondary Metabolites

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## TAKE HOME MESSAGE

Species selection and the ratio at which forbs are incorporated into grass pastures play a critical role in their use within warm-season systems. Forbs containing high concentrations of secondary metabolites may have reduced palatability, limiting voluntary intake and overall effectiveness. In this study, forbs were offered at a 30:70 ratio with bahiagrass to evaluate palatability and digestibility, but overall forb intake did not reach the targeted level. Consequently, dry-matter digestibility was similar across diets, reflecting the dominant contribution of bahiagrass to total intake. However, soybean-based forbs exhibited lower fiber digestibility than sunn hemp and lablab, indicating important species-specific limitations even at low intake levels.

## SUMMARY

Over the years, reaching a grazing period of 300 to 360 days has been a major goal for most beef cattle producers in the southeastern USA. Forbs such as lablab, soybean, and sunn hemp have gained popularity in this region due to their productivity and ability to bridge seasonal gaps when warm-season perennial grasses are less productive. The objective of this experiment was to evaluate how forage forb species containing various plant secondary metabolites (PSM) affected dry matter intake and nutrient digestibility in beef cattle. Forb intake reached a maximum of 8%, which was lower than the targeted level. Dry matter digestibility did not differ among diets ( $P = 0.18$ ). However, soybean-based diets showed reduced fiber digestibility ( $P < 0.05$ ) compared with the other forb options. Nitrogen utilization was not affected by diet ( $P \geq 0.39$ ), although retained nitrogen ranged widely (14–31%). Results indicated that, while forb inclusion may influence digestion and metabolism, palatability and voluntary intake may mask their potential.

## 1. INTRODUCTION

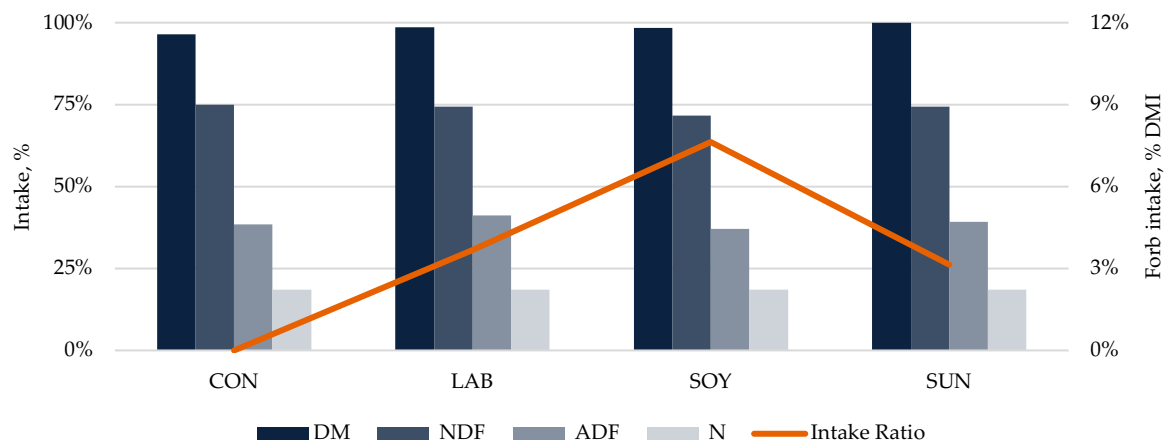
The pursuit of a year-round grazing system has become central to sustainable and cost-effective beef cattle production, especially given the high expenses associated with supplemental feeds. Warm-season forbs such as lablab, soybean, and sunn hemp help bridge seasonal forage gaps, providing cattle with consistent access to high-quality nutrition while contributing to soil improvement. When integrated into perennial grass pastures, these species strengthen grazing systems, enhance animal performance, and secure the long-term viability of beef production across the Southeast. Thus, **the objective of this study was to evaluate the palatability, intake behavior, and digestive patterns of selected forage forb species in beef cattle.**

## 2. PROCEDURES

A 4 × 4 Latin square design using four ruminally -fistulated steers was conducted at the Auburn University Stanley P. Wilson Beef Teaching Center. The experiment ran across four 22-day periods, consisting of 14 days for adaptation, 5 days for fecal and urine collection, and 3 days for rumen fluid collection. Four hay-based diets were evaluated: three warm-season forbs (lablab [LAB], soybean [SOY], or sunn hemp [SUN]) and a bahiagrass control (CON). Diets were offered as a 70:30 mix of grass to the assigned forb, and each steer received all four diets by the end of the study. During the collection phase, samples of feed, feed refusals, feces, urine, and rumen fluid were collected to evaluate nutritive value, intake, digestibility, and nitrogen absorption and retention.

## 3. RESULTS & DISCUSSION

Forb intake reached a maximum of 8% and remained well below the targeted inclusion ratio of 30% (Figure 1). Despite this limited consumption, total dry matter (DM;  $P=0.90$ ), neutral detergent fiber (NDF;  $P=0.84$ ), acid detergent fiber (ADF;  $P=0.31$ ) and nitrogen (N;  $P=0.19$ ) intake did not differ among diets, supporting the notion that steers primarily consumed the bahiagrass component of the diet.



**Figure 1.** Dry matter (DM), neutral detergent fiber (NDF), acid detergent fiber (ADF), nitrogen (N) intake, and forb intake ratio for cattle fed control (CON), lablab (LAB), soybean (SOY), or sunn hemp (SUN) diets. Means sharing the same superscript letter do not differ ( $P > 0.05$ ).

Dry matter digestibility was not affected by treatment ( $P=0.18$ ; Table 1), likely due to low-level forb intake. However, there was an effect on diet on NDF digestibility ( $P=0.03$ ) and ADF digestibility ( $P=0.02$ ), with SOY less than SUN and LAB ( $P < 0.05$ ). These differences likely reflect species-specific interactions with rumen fibrolytic microbes rather than a dominant contribution of forb intake to total diet composition. Nitrogen utilization, measured as apparently absorbed nitrogen and apparently retained nitrogen, did not differ among diets ( $P \geq 0.39$ ).

**Table 1.** Digestibility of grass-forb diets offered to beef steers in an evaluation of plant secondary metabolites.

Item <sup>1</sup>	Dietary treatments <sup>2</sup>				SEM <sup>3</sup>	P-value
	CON	LAB	SOY	SUN		
DMD	63.1	59.9	56.6	59.9	4.21	0.18
NDFD	75.7 <sup>a</sup>	72.5 <sup>ab</sup>	67.5 <sup>b</sup>	70.6 <sup>ab</sup>	2.52	0.03
ADFD	74.1 <sup>a</sup>	76.5 <sup>a</sup>	67.3 <sup>b</sup>	71.0 <sup>ab</sup>	2.85	0.02
AAN	57.5	52.7	57.8	51.0	7.41	0.53
ARN	28.5	24.7	31.4	14.1	7.33	0.39

<sup>1</sup> DMD = dry matter digestibility, % DM; NDFD = neutral detergent fiber digestibility, % NDF; ADFD = acid detergent fiber digestibility, % ADF; AAN = apparently absorbed nitrogen, % N; ARN = apparently retained nitrogen, % N.

<sup>2</sup> CON = control diet of bahiagrass hay, only; LAB = bahiagrass supplemented with lablab; SOY = bahiagrass supplemented with soybean; SUN = bahiagrass supplemented with sunn hemp.

<sup>3</sup> SEM = standard error of the mean

### Acknowledgments

Support for this project was provided by the Agricultural Research Service, U.S. Department of Agriculture, under Agreement No. 58-6010-1-005.

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# Clomiphene Citrate Enhances *in vitro* Early Embryonic Development of Porcine Oocytes

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## TAKE HOME MESSAGE

Improving the *in vitro* maturation (IVM) of livestock oocytes will increase the efficiency and use of *in vitro* fertilization as a source of embryos. IVF has the potential to accelerate genetic improvement and enhance livestock production efficiencies. IVM struggles due to a tendency to accumulate harmful reactive oxygen species (ROS) leading to poor embryo production. The use of the selective estrogen receptor modulator (SERM) clomiphene citrate (CC) as a supplement during oocyte maturation limits the accumulation of ROS and improves early embryo development.

## SUMMARY

*In vitro* reproductive technologies offer significant potential to accelerate genetic improvement and enhance reproductive efficiency in livestock systems. By reducing generation intervals and increasing selection intensity, these technologies can contribute to more sustainable production. However, current *in vitro* maturation (IVM) and embryo development rates remain suboptimal, limiting the overall effectiveness of these technologies. Therefore, our objective was to investigate the effects of Clomiphene citrate (CC), a selective estrogen receptor modulator (SERM), on porcine oocyte maturation and gene expression. We found that exposing oocytes to CC during maturation reduced the amount of reactive oxygen species which negatively affects embryo development (p-value < 0.05). Following parthenogenic activation we found that oocytes exposed to CC during maturation had a significantly higher percent developed into an embryo at 30 hours post activation (p-value < 0.05). Further investigation is required to determine if exposure to CC affects the ability of these embryos to generate offspring.

## 1. INTRODUCTION

*In Vitro* maturation of oocytes has become a pivotal technique in assisted reproductive technologies (ARTs) for various livestock species, including swine. This advanced reproductive technology could be beneficial in production systems due to the shorter generation time, increased genetic change, and maximization of superior genetics. However, the process of IVM is still undergoing optimization, partly due to the detrimental effects of reactive oxygen species (ROS). ROS are a significant factor in reducing oocyte quality and developmental competence (Khazaei and Aghaz, 2017).

Clomiphene citrate (CC), a selective estrogen receptor modulator (SERM), has gained considerable attention for its ability to stimulate ovulation and improve reproductive outcomes in humans and animals (Abe et al., 2020). Little is known about the function of CC exposure during IVM. With CC being a SERM, we propose that the antagonistic estrogenic properties of it may positively alter intracellular signaling, reducing the accumulation of ROS.

**The objective of the present study was to investigate the effects of CC supplementation during IVM on oocyte maturation rates, ROS accumulation, and early embryo development.** We hypothesize that the addition of CC into the culture media will encourage the resumption of meiosis, leading to decreased oxidative stress and improved early embryo development.

## 2. PROCEDURES

### 2.1 Animal care and use

All Duroc-Yorkshire cross ovaries were collected from gilts at the Auburn University abattoir, which originated from the Auburn University Swine Unit.

### 2.2 Sample collection

The ovaries were transported to the laboratory in a 0.9% saline solution at 37°C. In the laboratory, the ovaries were washed with 0.9% saline and maintained at 37°C during follicle aspiration. Follicles measuring 2-5 mm were aspirated using a 10 mL syringe and an 18G short bevel needle. The follicular content was placed into a 50 mL conical tube in a water bath at 37°C. Following settling the resulting pellet was then collected and transferred to a culture dish in warmed TL-HEPES. Only oocytes with at least three continuous layers of cumulus and a homogeneous cytoplasm were included in this study.

### 2.3 IVM and Activation

Cumulus-oocyte complexes (COCs) were collected and washed twice in North Carolina State University 23 (NCSU23) medium supplemented with 10% pFF, 0.1 mg/mL cysteine, and 10 ng/mL epidermal growth factor (EGF). Oocytes were then cultured for 22 h in the supplemented NCSU23 containing 10 IU/mL human chorionic gonadotropin (hCG) and equine chorionic gonadotropin (eCG), with the addition of 10<sup>-6</sup> M CC when applicable. Following this initial maturation period, oocytes were transferred to NCSU23 medium without gonadotropin supplementation or treatment for an additional 20-22 h. After 42-44 h in maturation, oocytes were stripped of cumulus cells mechanically with a glass Pasteur pipette in 80 IU/mL Hyaluronidase in TL-HEPES. Oocytes were then activated with 50 µM calcium ionophore (A23187) for 2 min. Oocytes were then washed in NCSU supplemented with 0.4% BSA and placed in 4-well plates.

### 2.4 DCFH-DA Staining

To determine if intracellular levels of ROS were different in CC treated oocytes, oocytes were matured and mechanically denuded with 80 IU/mL hyaluronidase. The denuded oocytes were then collected under a microscope and cultured for 30 min in 10µM 2'-7'-Dichloro-dihydrofluorescein diacetate (DCFH-DA). The stained oocytes were then washed briefly three times in 2% PBS-BSA and immediately imaged for fluorescence under an EVOS FL Cell Imaging System (ThermoFisher Scientific, Waltham, MA) using the GFP fluorescent filter. Staining intensity was quantified using ImageJ analysis software by calculating the corrected total cell fluorescence (CTCF, CTCF= Integrated Density-(Area of selected cell \* Mean fluorescence of background readings)) of five areas of an individual oocyte and averaging them.

### 2.5 Data analysis

Statistical analysis was conducted using GraphPad Prism software (v10.3.0). One-way ANOVA was implemented per replicate and treatment with a Tukey's post hoc testing for multiple comparisons. Comparisons were considered statistically significant if  $p < 0.05$  and considered trending significant if  $0.05 < p < 0.1$ .

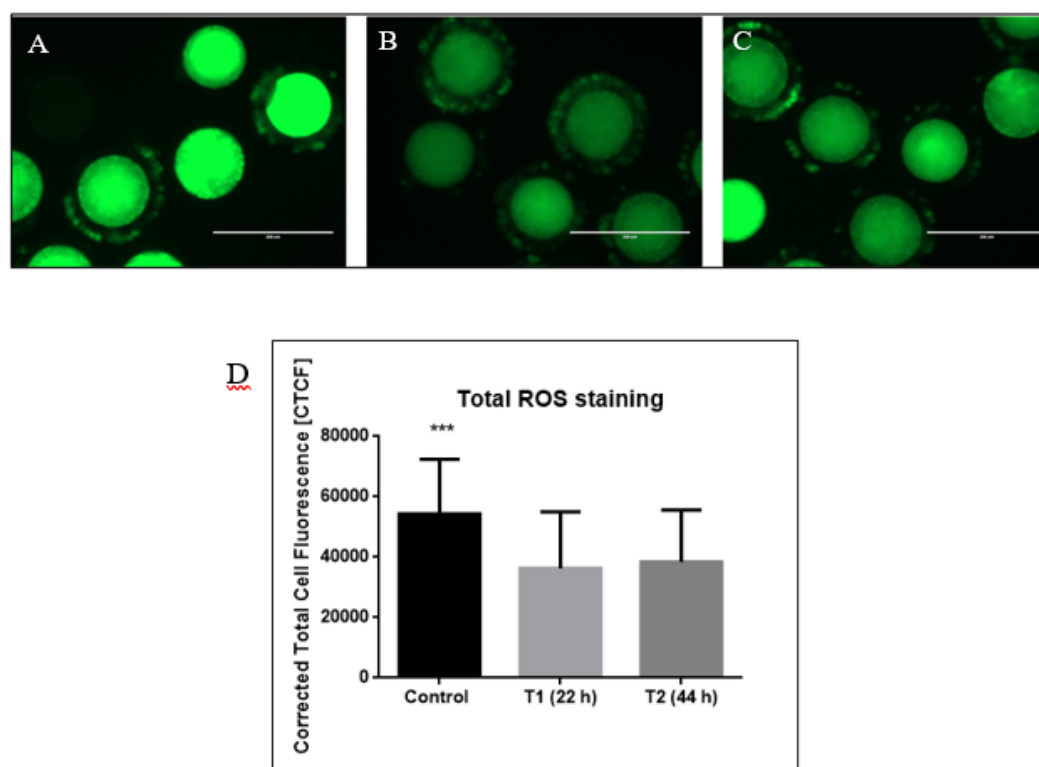
## 3. RESULTS & DISCUSSION

To determine the effect of CC on oocyte maturation, CC was added to the maturation medium for 22 h of the 44 h maturation. Three biological replicates were performed, with each group containing 70 oocytes assessed. Statistical analysis indicated no significant difference in maturity rates between the control and treated groups at this time point. These results are presented in Table 1.

**Table 1.** Maturity stages at 44 h of maturation in oocytes.

Stage	p-value	Control (%)	Treated (%)
GVBD	0.478	14.58±17.18	4.58±6.29
MI	0.940	36.42±12.71	35.53±11.22
MII	0.142	45.90±10.94	58.41±9.58

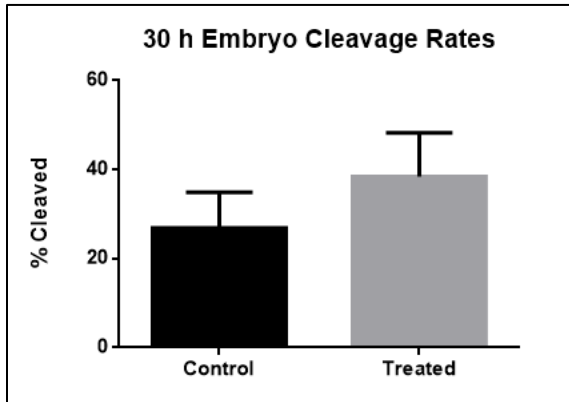
To assess free radical levels in oocytes after maturation with CC, DCFH-DA staining levels were compared between the treated and untreated control oocytes at 44 h. Oocytes exposed to CC for either 22 h or 44 h of the 44 h maturation exhibited significantly lower ROS levels, 36295±18768 CTCF and 38450±17194 CTCF, respectively, compared to the untreated controls, 54323±18110 CTCF ( $p < 0.0001$ ). These results are summarized in Figure 1.



**Figure 1.** DCHF-DA levels in Porcine Oocytes at 44 h A) Representative immunofluorescent image at 44h of the control porcine oocytes stained with DCHF-DA. B) Representative immunofluorescent image at 44h of the 22h treated porcine oocytes stained with DCHF-DA. C) Representative immunofluorescent image at 44h of the 44h porcine oocytes stained with DCHF-DA. D) Results showing the total fluorescence in the cell (CTCF) in treated and control groups. \*\*\*Denotes a significant difference,  $p < 0.0001$ . Error bars are  $\pm$  SD from the mean. 3 replicates were analyzed. Size bars in the immunofluorescence images represent 200 $\mu$ m.

Finally, we wanted to investigate the effect of CC inclusion on embryo development. A total of 8 independent replicates were conducted, with each experimental group comprising approximately 320 to 330 embryos. Statistical analysis revealed a significant difference in cleavage rates at 30 hours of activation between the treated and control groups ( $p = 0.022$ ). Specifically,

embryos in the treated group exhibited a higher mean cleavage rate of  $38.43 \pm 9.28\%$ , compared to  $26.86 \pm 8.08\%$  in the control group (Figure 2).



**Figure 2.** Average cleavage rates at 30 h in embryos. Treatment cleavage significantly more at 30 h than the control embryos ( $p=0.022$ ). Data is mean  $\pm$  SD.

The findings indicate that CC-treated oocytes had comparable maturation rates to untreated controls (Table 1). Interestingly, we found that exposure to CC during maturation decreased the accumulation of ROS during IVM (Figure 1). We found that CC exposure during IVM resulted in more embryos formed at 30 h post-parthenogenic activation. Accelerated cleavage has previously been associated with higher developmental competence in embryos, suggesting that CC may promote improved cytoplasmic maturation or metabolic readiness during early development (Fu et al., 2009). Further research is needed to determine if embryos generated following CC exposure can produce offspring.

### Acknowledgments

The authors would like to thank the staff at the Auburn Swine and Meats lab.

### Funding

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# Pre-breeding Maternal Micronutrient Supplementation & Developmental Programming in Beef Cattle

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## TAKE HOME MESSAGE

Early gestation is a critical window for fetal programming, during which maternal conditions can provide lasting effects on the offspring development and productivity. Maternal nutrition during this period plays a central role in shaping fetal growth through epigenetic mechanisms, particularly DNA methylation. In this study, we evaluated the effects of maternal vitamin and mineral supplementation on the hepatic DNA methylation profile of female bovine fetuses. Our results show that maternal supplementation significantly alters DNA methylation patterns in the fetal liver, affecting genes and pathways involved in gene regulation, cell proliferation, growth signaling, apoptosis, and metabolism. Notably, most differentially methylated genes were hypomethylated in fetuses from supplemented dams, suggesting increased transcriptional potential. These findings indicate that maternal vitamin and mineral supplementation may improve nutritional resource utilization to support fetal hepatic development. Further research is needed to determine whether these epigenetic modifications affect cattle performance and productivity outcomes.

## SUMMARY

Early gestation is a critical period for the establishment of pregnancy and fetal developmental programming in beef cattle, as maternal conditions during this window can have lasting effects on offspring performance. Maternal nutrition, particularly vitamin and mineral supply, plays a central role in regulating fetal development through epigenetic mechanisms such as DNA methylation. However, the biological pathways through which maternal micronutrient supplementation influences fetal tissue programming remain poorly understood. Therefore, we investigated the effects of maternal vitamin and mineral supplementation during early gestation on the hepatic DNA methylation profile of bovine fetuses. Our analysis identified 393 differentially methylated regions and 7,100 cytosines between supplemented and non-supplemented groups, affecting genes involved in gene regulation, protein processing, cell proliferation, growth signaling, and apoptosis. Notably, a predominance of 326 hypomethylated genes was observed in supplemented fetuses, suggesting enhanced transcriptional potential and improved utilization of nutritional resources to support fetal hepatic development.

## 1. INTRODUCTION

Fetal programming refers to the process by which environmental conditions during pregnancy influence the development of the fetus, leading to long-term effects on the calf's health and performance. Nutritional challenges during this critical period can change how fetal genes are regulated through

epigenetic mechanisms, affecting growth and development (Hammer et al, 2023). Although the entire gestation period is important, the first trimester of pregnancy is essential, as this is when placentation, organogenesis, and early muscle development occur.

One of the mechanisms involved with fetal programming is DNA methylation. This is an epigenetic process that regulates gene activity without changing the DNA sequence. Micronutrients, such as vitamins and minerals, play a key role in these processes by supporting normal methylation reactions in the body. The liver is especially important because it is responsible for metabolism and storage of many nutrients and helps regulate energy use throughout the body (Rui et al., 2014).

Previous studies have shown that nutritional challenges during early pregnancy can alter gene expression in fetal tissues, including the liver, muscle, and brain (Diniz et al., 2021). However, little is known about how these nutritional effects influence DNA methylation. Therefore, we hypothesized that providing vitamin and mineral supplementation from pre-breeding to early gestation could improve fetal development by altering DNA methylation in the fetal liver. **This study aimed to evaluate how maternal micronutrient supplementation affects liver DNA methylation and fetal developmental programming.**

## 2. PROCEDURES

### 2.1. Animals and experimental design

Crossbred Angus heifers (n = 16), ~16 months of age, were managed at the Central Grasslands Research and Extension Center (North Dakota State University) and assigned to either a vitamin and mineral supplemented (VTM, n = 8) or non-supplemented (NoVTM, n = 8) treatment from 71 days before breeding until day 83 of gestation. Heifers were group-fed a total mixed ration formulated to meet 100% of NRC requirements and artificially inseminated with female sex semen from a single sire. Pregnancy confirmation and fetal sex determination were performed at day 60 of gestation using transrectal ultrasonography, and only heifers carrying female fetuses remained in the study. On day 83 of gestation, heifers were ovariohysterectomized, fetuses were recovered, and fetal livers were collected, weighed, snap-frozen in liquid nitrogen, and stored at -80 °C until further molecular analyses. Hepatic DNA was isolated from fetal liver samples and used for downstream DNA methylation analysis via reduced representation bisulfite sequencing (RRBS).

### 2.2. Reduced Representation Bisulfite and DNA methylation

Raw sequencing data from RRBS were assessed for quality before downstream analyses. Following quality filtering and adapter trimming, reads were aligned to the bovine reference genome to obtain genome-wide DNA methylation profiles. Differential DNA methylation analyses were then performed using MethylKit to identify differentially methylated regions (DMRs) and differentially methylated cytosines (DMCs) between supplemented (VTM) and non-supplemented (NoVTM) groups, using the NoVTM group as the reference for comparison. DMRs and DMCs were considered statistically significant at q-value  $\leq 0.05$  and were classified as hypermethylated or hypomethylated based on methylation differences between treatments. The overall methylation profile was used to rank genomic features according to methylation differences and statistical significance. Gene lists associated with DMRs and DMCs were subsequently subjected to functional enrichment analyses using ShinyGo to identify biological pathways and cellular processes influenced by maternal vitamin and mineral supplementation.

## 3. RESULTS & DISCUSSION

We identified differences in the hepatic DNA methylation profile between fetuses VTM and NoVTM supplemented heifers. A total of 393 differentially methylated regions (DMRs) and 7,100 differentially methylated cytosines (DMCs) were identified, with approximately 326 DMR-associated genes being hypomethylated in the VTM group. These findings may suggest increased transcriptional potential in response to maternal supplementation. Differentially methylated genes included regulators of gene expression and developmental processes, such as *SOX10*, miR-503, and *UBE2D2*, and were over-

represented in pathways related to gene regulation, protein processing, and ubiquitin-mediated proteolysis.

Functional enrichment of DMC-associated genes revealed pathways involved in cell proliferation, growth signaling, apoptosis, and metabolic regulation, indicating enhanced cellular activity and developmental capacity in supplemented fetuses. To further explore the relationship between DNA methylation and transcriptional regulation, gene annotation using biomaRt and overlap analyses between DMGs and differentially expressed genes (DEGs) were performed. Differential expression analysis identified 118 genes between treatments, including 74 downregulated and 44 upregulated genes. Enriched pathways among DEGs included ABC transporters (*ABCB11* and *ABCC13*), metabolic pathways, coagulation cascade, sucrose metabolism, and receptor interaction. The lack of direct overlap between DMGs and DEGs suggests that additional regulatory mechanisms may contribute to gene expression differences beyond local DNA methylation.

Early gestation represents a highly sensitive window during which epigenetic modifications can influence tissue programming with potential long-term consequences. The predominance of hypomethylation observed in fetuses from supplemented dams suggests that maternal vitamin and mineral supplementation may enhance the utilization of available nutritional resources to support optimal fetal development. However, further integrative studies are needed to determine how DNA methylation and gene expression interact, whether these epigenetic changes persist throughout gestation and postnatal life, and how they ultimately contribute to offspring performance and productivity.

## Funding

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# Redesigning Extension: A Survey of Information Delivery Preferences in Equine Education

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## TAKE HOME MESSAGE

The purpose of this study is to determine audience preferences of online educational content delivery formats used in Extension outreach, specifically in equine extension education. Survey participants report preferring infographics or visual summaries, videos, and articles or written reports over interactive tools and webinars or online workshops for online educational content consumption. When provided three versions of the same information, participants reported preferring the infographic alone and article accompanied by a summarizing infographic compared to the article alone. Based on these findings, we recommend the delivery of information in more than one format to accompany text-based online Extension articles to meet audience preferences.

## SUMMARY

Information delivery methods can be tailored to meet audience preferences, but limited research focuses on the preferences of specific audiences served by Extension. A survey was conducted to determine participant (n = 131) preferences of educational content delivery formats used in equine extension education. Participants viewed a text-based article, visual summary infographic, and a combination of article and infographic based on Alabama Cooperative Extension System (ACES) publication “Estimating & Supplying Equine Forage Requirements” (Heaton, 2025). The survey was distributed through the Department of Animal Sciences and ACES social media and email channels. Only surveys that were fully completed by female respondents from southeastern states were analyzed. Speeders were also filtered out. Descriptive statistics were used to summarize respondent demographics and reported preferences. Participants with advanced experience in the equine industry reported frequent use of livestock management materials and more easily understood the article content than beginners. Age and experience influenced participant preference of online educational delivery method. No significant difference was found in ease of use or accessibility results based on age group or education level. Participants found versions including the infographic to be easier to use, more accessible, easier to understand, and more convenient than the article alone.

## 1. INTRODUCTION

The role of Extension is to provide research-based information and education to individuals and communities, including the translation of scientific findings into practical solutions for the improvement of agriculture, health, economic development and community well-being. Based on these goals, infographics may be useful tools for extension information dissemination. **The purpose of this study is to determine audience preferences of educational content delivery formats used in extension outreach, specifically in equine education.** Infographics convey complex information through visual summaries supported by limited text and are shown to increase interaction with extension materials (Lochner et al., 2021). Horse owners have also reported reliance on free sources such as social media and the internet over in-person events, pointing to the need for impactful and audience-specific online education (Stewart,

2025). By exploring audience preference of educational information delivery methods in equine outreach, this research aims to inform extension practices in the development and delivery of educational content.

## 2. PROCEDURES

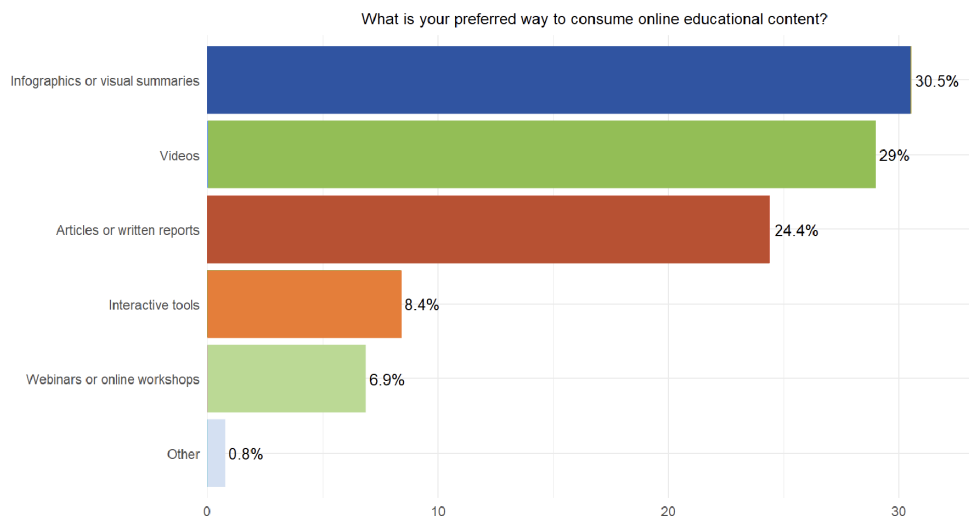
We designed a study to evaluate the preference of online educational content delivery from Extension, focusing primarily on participants in the equine industry as the intended audience. The Alabama Cooperative Extension System (ACES) peer-reviewed article “Estimating and Supplying Equine Forage Requirements” was selected as the example for text-based online extension education. Using the information in the article, a visual summary infographic was designed in Adobe Illustrator to convey key concepts in a concise and digestible format.

A 15-question Qualtrics survey was developed to assess participant preferences of online educational content delivery, specifically in equine education. Participants were asked to share demographic information including age range, gender, state of origin, education level, and years of experience in the equine industry. The survey was distributed through digital channels including Auburn University Department of Animal Sciences, Alabama Beef Systems Extension, and Alabama Equine Extension social media accounts and equine focused student organization communications on campus. Participants reported their frequency of use of livestock management guides and resources, online extension publications from their own state, and online extension publications from out of state universities/agencies. Respondents chose their preferred method of consuming online educational content. Following these introductory questions, participants viewed an embedded online article and infographic of the same topic in random order and reported their perceived ease of understanding of the information from each delivery method respectively. A combination of the article and infographic was then presented for review. Following the viewing of the three variations of information delivery (article alone, infographic alone, and article and infographic combined), participants were asked to choose which version was easiest to use, hardest to use, most likely to be shared with others, preferred for the type of information, most likely to be referenced first and revisited, and preferred to print for future reference. Qualitative responses were then collected to evaluate what was most desirable about the format the participants preferred and what they believed was missing from their preferred format.

Only surveys that were fully completed by female respondents from southeastern states were analyzed, filtering out speeders who completed the survey below half the median duration (Hillygus and LaChapelle, 2022). Descriptive statistics of percentages and measures of central tendency (mean) were used to summarize respondent demographics and reported preferences. Data analysis was conducted in R. Since data was not normally distributed, Kruskal Wallis tests were used for continuous/ordinal variables after checking for normality and Chi-squared tests were used for categorical variables. Dunn’s post-Hoc tests were used to analyze statistically significant differences identified between categorical variables. The data for online educational delivery was not suitable for Chi-Square. A Fisher’s Exact Test was conducted to test association between the groups and preferred way of consuming educational content.

## 3. RESULTS & DISCUSSION

No significant difference was found in ease of use or accessibility results based on age group or education level. However, age and experience influenced participant preference of online educational delivery method. The results show there is a statistically significant difference ( $p < 0.05$ ) in the use of livestock management guides and resources between experience groups. Beginners use livestock management guides less often than both Middle and Advanced experience in the equine industry, while Middle and Advanced experience respondents do not significantly differ. Participants ( $n = 130$ ) reported preferring to consume online educational content as infographics or visual summaries, videos, and articles or written reports over interactive tools and webinars or online workshops (Figure 1). Preferences differ significantly by age group ( $p = 0.004$ ) and experience level ( $p = 0.01$ ), but not by education (Tables 1 and 2).



**Figure 1.** Participants (n = 130) reported preferring to consume online educational content as infographics or visual summaries (n = 40), videos (n = 39), and articles or written reports (n = 32) over interactive tools (n = 11) and webinars or online workshops (n = 8).

**Table 1.** Fisher's Exact Test (Monte Carlo, 2000 reps) for Age group.

Age	Articles/ Written Reports	Infographics/ Visual Summaries	Videos	Interactive Tools	Webinars/ Online Workshops
Under 35	12.7% (9)	32.4% (23)	35.2% (25)	12.7% (9)	7.0% (5)
Middle Age (35-54)	35.6% (16)	35.6% (16)	15.6% (7)	4.4% (2)	8.9% (4)
Older (55+)	50.0% (7)	7.1% (1)	42.9% (6)	0.0% (0)	0.0% (0)
Total	98.2% (32)	75.1% (40)	93.6% (38)	17.1% (11)	15.9% (9)

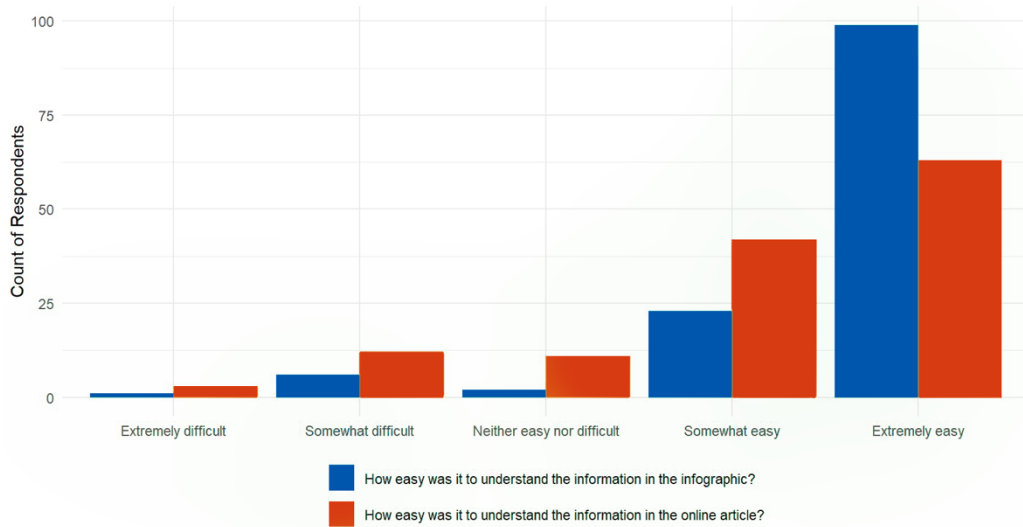
**Table 2.** Fisher's Exact Test (Monte Carlo, 2000 reps) for Experience group.

Experience	Articles/ Written Reports	Infographics/ Visual Summaries	Videos	Interactive Tools	Webinars/ Online Workshops
Beginner (0-5 years)	15.9% (7)	27.3% (12)	34.1% (15)	20.5% (9)	2.3% (1)
Middle (6-15 years)	20.6% (7)	44.1% (15)	20.6% (7)	2.9% (1)	11.8% (4)
Advanced (16+ years)	34.6% (18)	25.0% (13)	30.8% (16)	1.9% (1)	7.7% (4)
Total	71.1% (32)	96.4% (40)	85.4% (38)	25.3% (11)	21.7% (9)

When asked how easy it was to understand the information in the article alone, 47.3% (n = 62) of respondents reported extreme ease of understanding. When asked the same for the infographic alone, 74.3% (n = 98) reported extreme ease of understanding as seen in Figure 2. Ease of understanding was significantly different ( $p = 0.018$ ) between experience groups, with more experienced individuals finding the material easier to understand, while beginners struggled somewhat more.

Viewing order also had a significant effect on ease of understanding. A Kruskal-Wallis test followed by Dunn's post-hoc test indicated a significant difference in perceived ease of understanding between the reading order conditions ( $\chi^2$ ,  $p < 0.001$ ). Participants who viewed the article first (Article→Infographic, Mean = 4.85, SD = 0.56) understood the information in the infographic more easily than those who viewed

the infographic first (Infographic > Article, Mean = 4.39, SD = 0.94),  $Z = -4.13$ ,  $p < .001$ . Reading the article first appeared to provide context that made the infographic easier to understand.



**Figure 2. Respondents** found the summarizing infographic easier to understand (74.3%, n = 98) compared to a text-based article covering the same topic (47.3%, n = 62).

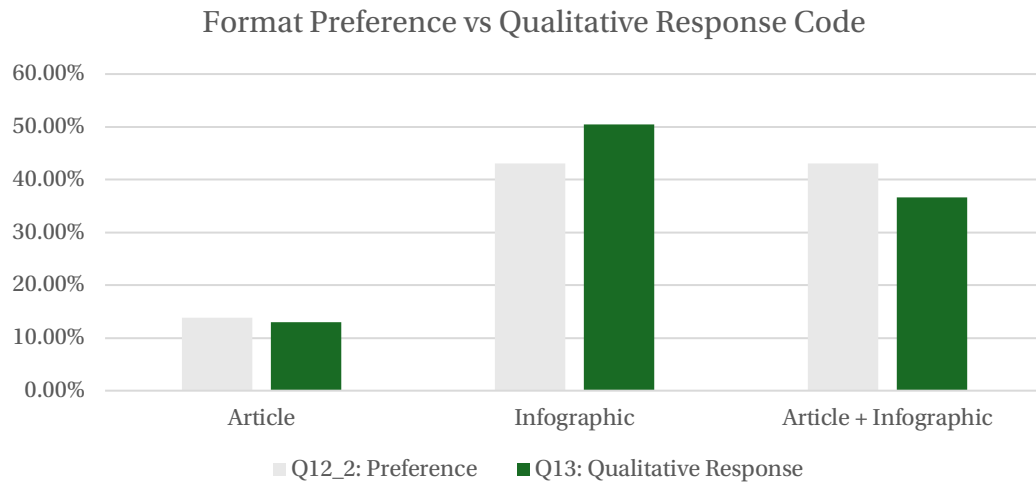
The infographic and article plus infographic combined were perceived as the most accessible and easy to use delivery styles, each receiving 45% (n = 59, n = 59) of participant selections respectively. When asked which format participants perceived as the least accessible or hardest to interact with, 77.1% (n = 101) chose the article alone. Overall, participants reported the infographic alone and the article and infographic combined as the preferred formats for equine extension information delivery (42.7% infographic, n = 56; 42.7% article + infographic, n = 56) compared to 13.7% (n = 18) preferring the article alone as seen in Figure 3. Participants preferred a delivery method including the infographic on first reference if they were seeking information on the topic (65.6%, n = 81) or revisiting content at a later time (73.3%, n = 96).



**Figure 3. Respondents** generally preferred formats including the infographic over the article alone.

Qualitative responses were collected, with respondents who preferred a format including the infographic reporting ease of use, aesthetic appeal, convenience, and simplicity. Those preferring the article alone enjoyed the increased detail, specificity, and realistic images. Participants included that they would be interested in additional communication formats and tools including a video, podcast, links to related topics with more information, or direction to additional resources showing how to perform the discussed practices (e.g. how to score body condition, estimate weight, or formulate a ration).

Figure 4 represents the response breakdown in percentages of preferred information delivery method between responses for Question 12\_2 (Which format do you prefer for this type of information, n=130) and Question 13 (What did you find most desirable about the format you preferred, n=123). Qualitative responses show an even greater preference for the infographic alone compared to the article and infographic combined and article alone.



**Figure 4.** Respondents identified their preferred format for the type of information presented in the survey in Question 12\_2. Percent breakdown of responses is as follows: 13.84% preferred the article alone, 43.08% preferred the infographic alone, and 43.08% preferred the article and infographic combined. In comparison, qualitative responses to Question 13 were hand coded to reflect the format discussed in participant responses: 13.01% of responses were in reference to the article alone, 50.40% to the infographic alone, and 36.59% to the article and infographic combined.

Evaluation of audience preferences provides beneficial insights for Extension educators. Redesigning content delivery methods to meet audience preference may increase use and application of extension resources and allow efforts to be put toward the most impactful formats. The equine industry is highly engaged and present in online communities, amplifying the need to provide clear, accurate information in accessible formats. Use of multiple media for communication reduces media-specific barriers to communication among learners and increases the opportunities to develop a wider range of expression in a media-rich world (Center for Applied Special Technology, 2024). Based on the findings of this study, we recommend that similar surveys be conducted across audiences served by Extension to assess the ideal information delivery methods by audience preferences. Further, future research should explore the additional online education methods identified in qualitative responses, as these may offer valuable insights into accessible strategies for Extension education and outreach.

## Acknowledgments

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The Auburn University Institutional Review Board has approved the presentation of study findings. Protocol #STUDY00000816

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# Strengthening Public Understanding of Animal Agriculture: Insights from the Veracis™ Communication Research Program

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## TAKE HOME MESSAGE

The Veracis™ research program examines how individuals interpret information about livestock production, how misinformation is recognized or perpetuated, and how different communication approaches can improve understanding of agricultural systems. This research integrates perspectives from agricultural education, communication science, and livestock production to identify strategies that improve agricultural literacy among educators, students, and consumers.

## SUMMARY

Public perceptions of livestock production increasingly influence food purchasing decisions, agricultural policy, and the long-term sustainability of animal agriculture. Over the past several decades, fewer consumers have direct experience with farming and ranching, contributing to a growing disconnect between agricultural production systems and the public. This disconnect has created opportunities for misinformation to spread regarding animal welfare, environmental impacts, and the role of meat in human diets.

To better understand how individuals form opinions about animal agriculture and how those opinions can be influenced through educational communication strategies, my research program developed the Veracis™ Communication research initiative. The term *Veracis* reflects a focus on truth-based communication and emphasizes the importance of accurate, science-informed information in public discourse about agriculture.

### 1. Our Research Approach

The Ag communication research initiative, unique among animal science programs, incorporates multiple research methods to examine how individuals interpret information related to livestock production. These methods include surveys, experimental studies, sentiment and perception analysis, and communication trials using digital media platforms.

Several studies have examined how individuals in higher education evaluate the credibility of information related to agriculture. These studies assessed whether instructors of different disciplines and other educated audiences can accurately distinguish between scientifically supported information and misleading claims about livestock production systems. Some of these investigations explored potential for showing bias and misinformation in university courses.

Other studies have explored how communication formats influence audience engagement and understanding. Research has evaluated the effectiveness of instructional videos, infographics, and social media content in communicating complex agricultural topics to broader audiences.

The program has also examined how digital communication platforms, including social media, podcasts, and online educational content, can be used to reach audiences that may not have traditional exposure to animal agricultural production systems.

Collectively, these approaches provide deeper insight into how different audiences interpret agricultural information and which communication strategies are most effective for improving public understanding.

## 2. Key Findings from Veracis™ Communication Research

### *Knowledge Gaps and Misconceptions Persist*

One consistent finding across studies is that misconceptions about animal agriculture exist even among well-educated audiences. In some cases, individuals who regularly consume media related to food systems still demonstrate limited familiarity with modern livestock production practices.

These misconceptions often relate to environmental sustainability, animal welfare practices, and the role of meat in human nutrition. Importantly, our research suggests that misunderstandings frequently arise from incomplete information rather than intentional bias, indicating an opportunity for improved educational outreach.

### *Credibility Judgments Are Influenced by Message Framing*

Research within the Veracis™ initiative has shown that the way information is framed can significantly influence whether individuals perceive it as credible. Messages that present balanced, evidence-based information (also referenced as cognitive information) and acknowledges the complexity of agricultural systems are more likely to be trusted than messages that appear overly promotional or dismissive of environmental concerns.

The collective findings to-date suggest that communication strategies should emphasize transparency and appropriate level of scientific evidence while also acknowledging the values and concerns of the audience.

### *Visual and Multimedia Communication Can Improve Understanding*

Studies evaluating communication tools such as informational or instructional videos and infographics demonstrate that visual communication formats can help audiences better understand complex agricultural systems. When properly designed, these tools can convey information about sustainability practices, animal care, and production systems in ways that are more accessible than traditional text-based communication. For example, short instructional videos that combine factual information with storytelling elements can improve both cognitive understanding and emotional engagement with agricultural topics.

### *Social Media Platforms Provide Opportunities for Agricultural Outreach*

Digital communication platforms continue to play a growing role in shaping public perceptions of agriculture yet use in podcasting for education or extension programming is underutilized. Research examining platforms such as Instagram suggests that visual storytelling can be an effective tool for sharing agricultural experiences and production practices with broader audiences. Perceptions are heavily influenced by emotional imagery and trust accelerates with combined accurate cognitive information.

While there are great opportunities for further research, these social media platforms allow agricultural communicators to reach individuals and both ag and non-ag social media influencers who may not otherwise seek out information about livestock production. However, effective communication requires thoughtful message design and attention to audience engagement.

### *Educational Interventions Can Influence Perceptions*

Research evaluating communication interventions indicates that targeted educational materials can influence how individuals perceive sustainability and animal agriculture. When audiences are provided with clear, evidence-based information about livestock production practices, many demonstrate increased understanding of the environmental, nutritional benefits of animal derived foods, animal wellness practices and economic contributions of the livestock sector.

This research suggests that educational communication strategies can play an important role in improving public understanding of agriculture. It is imperative that greater effort to reach all levels of

informal, non-formal, and formal teaching and learning programs. sector can strategically influence educators and learners by implementing hands-on, experiential learning, such as livestock projects, farm tours, and classroom-integrated curriculum, to foster understanding of animal agriculture's role in food production. Partnering with educators to provide, evidence-based, unbiased information helps address misconceptions, highlighting the economic, nutritional, and environmental aspects of animal husbandry.

### 3. Implications for the Livestock Industry

The findings from the Veracis™ communication research program highlight several important considerations for producers, educators, and industry organizations. First, the livestock industry must continue to prioritize transparent communication about production practices. Consumers increasingly seek information about how food is produced, and accessible communication can help build trust and confidence. Second, educational institutions and extension programs play a critical role in improving agricultural literacy. Faculty, extension specialists, and industry educators serve as trusted sources of information and can help bridge the gap between producers and the public.

Third, modern communication strategies should incorporate digital platforms and multimedia tools to effectively reach younger audiences. Social media, podcasts, and video-based educational resources provide opportunities to share accurate information about livestock production in engaging ways. Finally, continued research is needed to better understand how different audiences interpret agricultural information and how communication strategies can be adapted to address evolving public concerns about food systems (Figure 1).



**Figure 1.** Key takeaways of the Veracis™ Communication research framework for producers and industry leaders.

### 4. Future Research Directions

Future work within the Veracis™ research initiative will continue to examine communication strategies that promote accurate and balanced understanding of livestock production systems. As public discourse surrounding animal agriculture increasingly intersects with issues of sustainability, nutrition, animal welfare, and rural livelihoods, research efforts will focus on identifying approaches that foster constructive dialogue between agricultural producers, scientists, policymakers, and the broader public.

Building on prior studies, future research will continue to explore how science-based agricultural messaging influences perceptions of meat and livestock production and informs policy discussions related to food systems. Emphasis will be placed on evaluating whether communication interventions, such as visual media, digital storytelling, and producer-centered narrative, lead to lasting changes in knowledge, attitudes, and trust in agricultural institutions.

Another important direction involves expanding educational tools that strengthen agricultural literacy across diverse audiences, including educators, students, and consumers who may have limited direct exposure to food production systems. These efforts will support the development of accessible, evidence-informed resources that help individuals better understand the role of livestock agriculture in food systems, environmental stewardship, and rural economies.

Consistent with global discussions about the societal role of livestock, future research will also consider how communication strategies can better articulate the multifunctional contributions of animal agriculture. Livestock systems provide nutrient-dense foods, support the livelihoods of rural communities, utilize land resources not suitable for crop production, and contribute to integrated agricultural landscapes. Understanding how these contributions are communicated—and how they are interpreted by different audiences—represents a critical research priority.

In this context, the Veracis™ initiative seeks to advance communication approaches that encourage informed and respectful dialogue about livestock agriculture. By grounding messaging in scientific evidence and transparent engagement, research in this area can help support thoughtful decision-making related to food systems, strengthen trust between producers and consumers, and contribute to resilient agricultural communities.

## 5. Conclusion

As public interest in food production continues to expand, the livestock industry must navigate an increasingly complex communication and anti-animal Ag activism landscape. Research from the Veracis™ Communication initiative demonstrates that thoughtful, evidence-based communication strategies can improve understanding of livestock production systems and strengthen trust between producers and consumers.

By integrating research, education, and outreach, agricultural institutions can play an important role in ensuring that accurate information about livestock production is accessible to the public. Continued efforts to improve agricultural communication will be essential for supporting informed decision-making, strengthening rural economies, and sustaining the future of animal agriculture.

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