Effects of diet digestibility on feed efficiency and impact of diet type and feeding phase on repeatability of feed efficiency phenotype

S. L. Hansen, J. R. Russell, N. O. Minton, W. J. Sexten, M. S. Kerley, E. L. Lundy, E. K. Niedermayer, and National Program for Genetic Improvement of Feed Efficiency in Beef Cattle*

Introduction

- Cattle grown with roughage-based diets
  - Finished with high concentrate diets
- Measuring DMI, FE: expensive, labor-intensive (Arthur and Herd, 2008)
  - Cattle often FE tested once during growing phase
- FE phenotype repeatable across diet types and feeding phases?
  - How do growth and carcass traits differ between FE phenotypes?

Introduction

- FE repeatability from growing to finishing phase
  - Heifers fed similar diets (Kelly et al., 2010)
    - DMI (R = 0.61)
    - RFI (R = 0.62)
    - G:F (R = 0.37)
  - Steers fed similar diets (Durunna et al., 2011)
    - RFI (R = 0.42, 0.44)
    - G:F (R = 0.29, 0.38)
  - Steers fed differing diets (Durunna et al., 2011)
    - RFI (R = 0.33)
    - G:F (R = 0.20)

Influence of growing phase feed efficiency on finishing phase growth performance and carcass characteristics of beef steers fed different diet types

Russell et al. 2016. J. Anim. Sci..
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Objective

Determine the influence of growing phase FE classification and diet type on performance of steers fed differing finishing phase diets

Experimental design

- Six groups, 985 steers total
- Growing Phase
  - University of Missouri
  - Dirt lots with Growsafe bunks
    - Corn-based (**G-Corn**)
    - Roughage-based (**G-Rough**)
  - 2 d start/end weights
  - Individual DMI measured, 69-89 d
  - Intermediate weights taken 14-28 d

Growing phase diet nutritional analyses

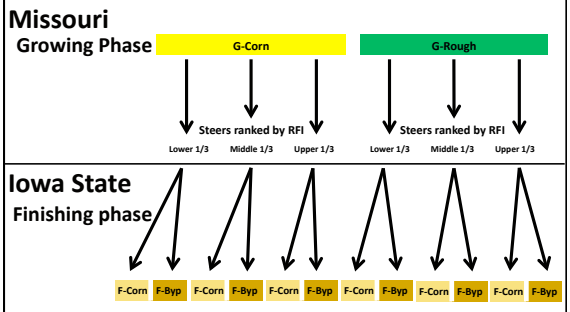
Nutritional analysis[2], % DM	Group[1] 1, 2, 3	4	5	6
G-Corn				
DM, % as-fed	90.7	90.3	88.3	85.1
NDF	17.8	20.2	21.1	26.4
ADF	4.4	5.0	4.9	6.5
CP	17.2	17.9	23.1	20.5
G-Rough				
DM, % as-fed	79.4	68.9	68.3	66.8
NDF	50.1	46.9	52.3	57.5
ADF	32.5	26.5	29.0	31.5
CP	17.2	16.0	22.3	20.8

[1] Roughage-based diet was not fed during group 2.
[2] Determined from analysis of total mixed rations.

Experimental design

- Finishing Phase
  - Iowa State University
  - Concrete pens, 5-6 steers/pen
    - Steers blocked to pens
      - Growing phase diet
      - RFI Ranking
        - Upper, middle, lower one-third
  - Transitioned to finishing phase diets
    - Corn-based (**F-Corn**)
    - Byproduct-based (**F-Byp**)

Experimental design



Finishing phase diets

Ingredients, % DM	F-Corn	F-Byp
Cracked corn	75	30
Dried distillers grains	14.99	39.99
Bromegrass hay	8	8
Soybean hulls	-	20
Limestone	1.54	1.54
Sodium chloride	0.31	0.31
Vitamin A premix[1]	0.11	0.11
Trace mineral premix[2]	0.035	0.035
Rumensin 90[3]	0.013	0.013
Nutritional analysis[4], % DM		
DM, % as-fed basis	84.5	84.1
NDF	24.4	42.7
ADF	8.0	18.7
CP	11.2	18.4

[1] Vitamin A premix contained 4,400,000 IU/kg.
[2] Provided per kilogram of diet (from inorganic sources): 30 mg Zn, 20 mg Mn, 0.5 mg I, 0.1 mg Se, 10 mg Cu, 0.1 mg Co.
[3] Provided Monensin at 200 mg·steer·1·d·1, Elanco Animal Health, Indianapolis, IN.
[4] Determined from analysis of total mixed rations.

FE classification

- After group 6 was completed
  - 985 total steers, 168 finishing phase pens
- Average growing phase G:F
  - Finishing phase pen
    - Covariate - growing phase initial BW
- FE classifications assigned within growing phase diet
  - Lowly feed efficient (**LFE**, < 0.5 SD from G:F mean)
  - Mid feed efficient (**MFE**, ± 0.5 SD from G:F mean)
  - Highly feed efficient (**HFE**, > 0.5 SD from G:F mean)

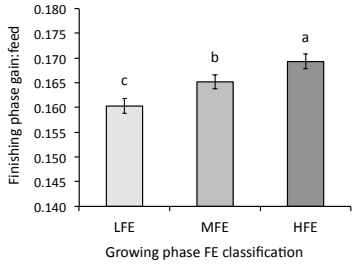
Descriptive statistics of growing phase FE classifications calculated for finishing phase pens

	G-Corn			G-Rough		
	LFE	MFE	HFE	LFE	MFE	HFE
Pens (n)	25	41	24	24	34	20
G:F[1]						
Average	0.180	0.218	0.258	0.169	0.196	0.228
Minimum	0.141	0.203	0.235	0.144	0.185	0.211
Maximum	0.202	0.233	0.298	0.183	0.208	0.262

[1] Growing phase G:F for each finishing phase pen calculated using individual BW and DMI data for each steer housed in a finishing phase pen, and utilizing growing phase initial BW as a covariate in the MIXED procedure of SAS 9.3 (SAS Institute Inc., Cary, NC).

Finishing phase G:F due to FE classification

- No interaction effects ($P \geq 0.5$)



[a, b, c] Bars without common superscript differ ($P \leq 0.05$)

Reclassification

Table 6. Effect of growing phase and finishing phase diets on feed efficiency classification shifts by steers and the correlation between growing phase and finishing phase G:F.

		Percent of pens changing feed efficiency classifications from growing to finishing			Correlation of G:F between phases[1]
Item	Pens (n)	No change	One classification	Two classifications	r (*P*-value)
G-Corn	90	51.1%	41.1%	7.8%	
F-corn	45	48.9%	40.0%	11.1%	0.47 (0.001)
F-Byp	45	53.3%	42.2%	4.4%	0.40 (0.007)
G-Rough	78	41.0%	42.3%	16.7%	
F-Corn	39	43.6%	43.6%	12.8%	0.37 (0.02)
F-Byp	39	38.5%	41.0%	20.5%	0.29 (0.08)
Overall	168	46.4%	41.7%	11.9%	

Finishing phase growth traits as affected by growing phase diet and feed efficiency classification

	G-Corn			G-Rough				
Item	LFE	MFE	HFE	LFE	MFE	HFE	SEM	*P*[1, 2]
IBW[3], kg	448	457	459	460	462	475	-	-
FBW[4, 5], kg	615^{ab}	609^{bc}	605^{c}	605^{c}	612^{ab}	618^{a}	2.6	0.001
ADG, kg/d	1.85^{ab}	1.79^{bc}	1.78^{bc}	1.72^{c}	1.82^{ab}	1.87^{a}	0.029	0.005
DMI[5], kg/d	11.3^{a}	10.7^{bc}	10.6^{c}	11.0^{ab}	11.1^{a}	11.2^{a}	0.12	0.002

[a, b, c] Least squares means in a row without common superscript differ ($P < 0.05$).
[1] Interaction effect of growing phase diet and feed efficiency classification.
[2] Growing phase diet × feed efficiency classification interaction was not significant ($P = 0.14$) for G:F;
[3] Initial BW pencil shrunk 4%.
[4] Final BW, pencil shrunk 4%.
[5] Initial BW applied as a covariate.

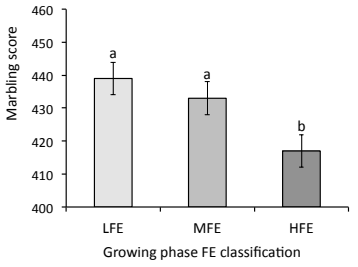
Carcass traits as affected by growing phase diet and feed efficiency classification

	G-Corn			G-Rough				
Item	LFE	MFE	HFE	LFE	MFE	HFE	SEM	*P*[1, 2]
HCW[3], kg	389^{a}	386^{a}	381^{b}	385^{ab}	387^{a}	390^{a}	1.9	0.003
REA[4], cm^2	86.6^{c}	89.6^{b}	87.9^{bc}	87.9^{bc}	89.1^{b}	91.7^{a}	0.78	0.01

[a, b, c] Least squares means in a row without common superscript differ ($P < 0.05$).
[1] Interaction effect of growing phase diet and feed efficiency classification.
[2] Growing phase diet × feed efficiency classification interaction was not significant ($P \geq 0.2$) for dressing percent, backfat, KPH, yield grade, or marbling score.
[3] Initial BW applied as a covariate.
[4] Ribeye area.

Marbling score due to FE classification

- No interaction effects ($P \geq 0.2$)



[a, b] Bars without common superscript differ ($P \leq 0.05$)

Summary-Part I

- FE relatively repeatable across feeding phases
  - HFE > MFE > LFE
    - Corn-grown steers: DMI drove G:F
    - Roughage-grown steers: ADG drove G:F
- Growth and carcass differences
  - Limited differences in corn-finished steers
  - Differences driven by steers fed fibrous diets
    - Variation in fiber utilization?

Influence of feed efficiency classification on diet digestibility and growth performance of beef steers

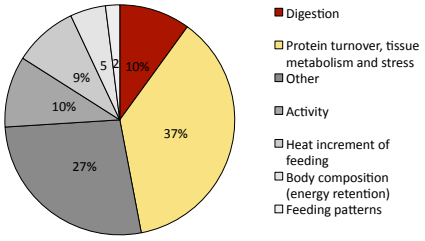
Russell et al. 2016. J. Anim. Sci.. 94: 1610-1619.

Introduction

- Positive correlation between diet digestibility and feed efficiency (Nkrumah et al., 2006)
- Greater diet DM digestibility in efficient bulls and heifers (Richardson et al., 1996)
- Is diet digestibility greater in cattle with greater FE?

Contributors to variation

- Many physiological mechanisms contribute to FE variation between individuals (Richardson and Herd, 2004)



Objectives

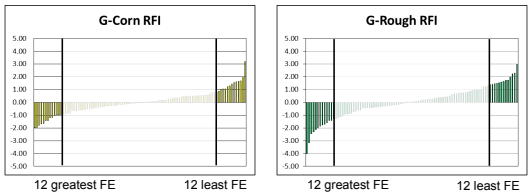
Determine effects of growing phase diet, growing phase FE classification, and finishing phase diet on diet digestibility and finishing phase FE.

Experimental design

- Two groups
  - Growing phase
    - University of Missouri
      - Corn-based (**G-Corn**)
      - Roughage-based (**G-Rough**)
    - FE phenotyped
  - Finishing phase
    - Iowa State University
      - Corn-based (**F-Corn**)
      - Byproduct-based (**F-Byp**)

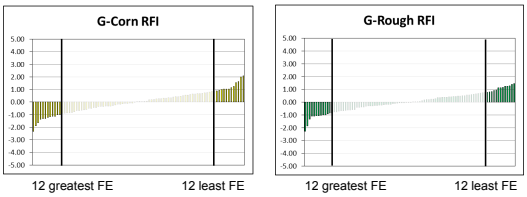
Digestibility group 1 selection

- G-Corn – 97 steers total
- G-Rough – 94 steers total
- 12 greatest FE, 12 least FE from each diet

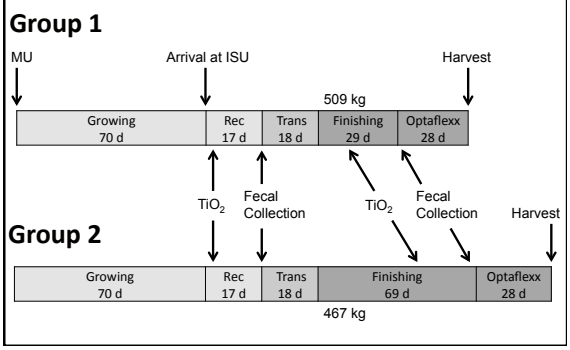


Digestibility group 2 selection

- G-Corn – 88 steers total
- G-Rough – 94 steers total
- 12 greatest FE, 12 least FE from each diet



Timeline



FE classification

- Growing phase G:F values pooled from both groups
  - 48 steers/diet (G-Corn, G-Rough)
- Steers ranked by growing phase G:F within diet
  - 24 greatest FE (**HFE**)
  - 24 least FE (**LFE**)

Growing phase diet digestibility as affected by growing phase diet and FE classification

	G-Corn		G-Rough			*P*-value[2]		
Item	LFE	HFE	LFE	HFE	SEM	G-Diet	FE	G-Diet × FE
DM[1], %	65.4	65.9	65.5	72.4	3.39	0.2	0.13	0.2
OM[1], %	67.7	67.5	68.3	74.2	2.38	0.14	0.2	0.2
NDF, %	58.8^{b}	56.7^{b}	60.4^{b}	71.7^{a}	3.80	0.003	0.09	0.02
ADF, %	45.7^{z}	47.1^{z}	58.2^{y}	71.3^{x}	3.45	<0.001	0.04	0.095
CP, %	58.9	57.2	60.4	65.4	4.40	0.6	0.6	0.2
Starch, %	85.9	86.0	91.1	92.8	2.20	0.007	0.7	0.7

[a, b] Least squares means in a row without common superscript differ ($P < 0.05$)
[x, y, z] Least square means in a row without common superscript tend to differ ($P < 0.10$)
[1] Titanium feeding period DMI applied as a covariate
[2] *P*-values: Diet = main effect of growing phase diet; FE = main effect of growing phase feed efficiency classification; Diet*FE = interaction effect of growing phase diet and feed efficiency classification

Finishing phase performance as affected by growing phase FE classification

Item	LFE	HFE	SEM	*P*-value
Initial BW, kg	495	481	-	-
Final BW[1], kg	618	619	5.0	0.8
ADG, kg/d	1.75	1.78	0.065	0.6
DMI[1], kg/d	11.8	11.3	0.27	0.11
G:F[1]	0.149	0.158	0.0045	0.04

[1] Initial BW applied as a covariate

Growing phase FE classification had no effect on finishing phase diet digestibility

Dry matter digestibility correlations across growing and finishing phase diets

Growing phase diet	Finishing phase diet	r[1]	*P*-value
Corn	Corn	0.49	0.02
Corn	Byproduct	0.25	0.3
Roughage	Corn	0.21	0.4
Roughage	Byproduct	0.68	<0.001

[1] Pearson's correlation coefficient

Summary- Part II

- Is diet digestibility greater in cattle with greater FE?
  - Growing phase diet digestibility greater in HFE vs LFE
    - Driven by roughage-fed cattle
  - No growing phase FE classification effect on finishing phase diet digestibility ($P > 0.6$, data not shown)
  - Diet digestibility correlated between phases when grown/ finished on similar diets

Overall conclusions

- FE was repeatable from the growing to finishing phase
  - Corn-grown steers - DMI drove G:F
  - Roughage-grown steers - ADG drove G:F
  - Negative correlation between phases in G-Rough/F-Corn steers
- Variation between FE classifications
  - Limited growth and carcass differences
    - Decreased marbling as FE improved
- Diet digestibility influences on FE-especially roughage

Overall implications

- How can we use this data to manage cattle better?
  - Breeding stock selection
  - Terminal animal management
    - Phenotype
    - Genotype
      - All steers were genotyped
  - Identify cattle that excel under certain conditions
    - Diet, production environment
  - Improve economic and environmental sustainability

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Questions?