Effects of Syngenta Enogen Feed Corn containing an α-amylase trait on finishing cattle performance and carcass characteristics[1]

M. L. Jolly-Breithaupt,[†] M. E. Harris,[†] B. L. Nuttelman,[†] D. B. Burken,[†] J. C. MacDonald,[†] M. K. Luebbe,[†] T. K. Iragavarapu,[‡] and G. E. Erickson[†,2]

[†]Department of Animal Science, University of Nebraska, Lincoln, NE 68583; [‡]Syngenta Seeds LLC, Minnetonka, MN 55305

ABSTRACT: Two experiments evaluated the effects of feeding a new corn hybrid, containing an α-amylase enzyme trait, Syngenta Enogen Feed Corn (SYT-EFC), on feedlot performance and carcass characteristics at two locations. Experiment 1 utilized 300 calffed steers (298.5 ± 16.3 kg of BW) at the University of Nebraska–Lincoln Eastern Nebraska Research and Extension Center Mead, NE. Treatments were designed as a 2 × 2 + 1–factorial arrangement with factors consisting of 1) corn type (SYT-EFC or conventional [CON]) and 2) byproduct type (with or without Sweet Bran [SB]), or a BLEND of STY-EFC and CON without SB. In Exp. 2, 240 crossbred, calf-fed steers (287.6 ± 15.4 kg of BW) were utilized at the University of Nebraska–Lincoln Panhandle Research and Extension Center near Scottsbluff, NE. Steers were fed SYT-EFC, CON, BLEND, or CON with a commercial α-amylase enzyme supplement (CON-E). In Exp. 1, there was an interaction for ADG ($P = 0.05$) and G:F ($P = 0.02$). Steers fed SYT-EFC with SB had greater ADG and G:F than CON; however, in diets without SB, SYT-EFC and CON were not different resulting in a 10.1% change in G:F when steers were fed SYT-EFC in SB compared with CON and only 1.6% change between SYT-EFC and CON without SB. Energy values, based on performance data, resulted in a 6.5% and 8.3% change in NE_m and NE_g, respectively, for steers fed SYT-EFC and CON with SB and 1.6% change for both NE_m and NE_g for steers fed SYT-EFC and CON without SB. For the main effect of corn trait, steers fed SYT-EFC had greater marbling scores, fat depth, and calculated yield grade compared with CON ($P \leq 0.03$). In diets without SB, there was no difference between SYT-EFC, CON, or BLEND for DMI, final BW, ADG, G:F, NEm, or NEg ($P \geq 0.35$). In Exp. 2, cattle fed SYT-EFC, BLEND, or CON-E had greater final BW, ADG, and G:F than cattle fed CON ($P \leq 0.03$). On average, NE_m and NE_g were 4.9% and 7.0% greater, respectively, for steers fed amylase enzyme treatments compared with CON ($P \leq 0.01$). Hot carcass weights were greater in steers fed α-amylase treatments compared with CON ($P < 0.01$). Feeding Syngenta Enogen Feed Corn, which contains an α-amylase enzyme trait, at both locations improved feed efficiency in finishing cattle diets containing WDGS or SB.

Key words: α-amylase, beef cattle, corn trait, feedlot

Transl. Anim. Sci. 2019.3:504–512
doi: 10.1093/tas/txy121

---

[1] A contribution of the University of Nebraska Agricultural Research Division supported in part by funds provided by Syngenta Seeds LLC (Minnetonka, MN).

[2] Corresponding author: gerickson4@unl.edu

Received August 21, 2018.
Accepted November, 20, 2018.

INTRODUCTION

Corn is the most widely utilized source of grain in finishing cattle diets in the United States (Vasconcelos and Galyean, 2007). Comprising roughly two thirds of corn grain by weight, starch is a major energy component of feedlot diets. To achieve optimal cattle performance, starch digestion must be maximized but ruminal acidosis may occur from rapid ruminal starch digestion (Owens et al., 1998). Two traditional approaches that have been utilized to improve feed efficiency and starch utilization are corn processing methods, such as rolling, ensiling, or flaking (Hale, 1973; Owens et al., 1997; Huck et al., 1998), and the use of different corn hybrids (Jaeger et al., 2006; Luebbe et al., 2009).

Feeding exogenous enzymes can be an alternative method to improve feed efficiency in finishing diets. Most research available on feeding exogenous enzymes in feedlot diets have analyzed the use of fibrolytic enzymes to increase fiber digestion (Beauchemin et al., 1995). However, the addition of exogenous α-amylase in grain-based finishing diets has been variable, either improving ADG 6.5% to 11.9% (Burroughs et al., 1960; Tricarico et al., 2007) or not affecting ADG (DiLorenzo et al., 2011). However, although not significant ($P = 0.55$), DiLorenzo et al. (2011) observed a 9.5% increase in G:F for steers fed supplemental amylase compared with the control.

In 2011, Syngenta Seeds LLC (Minnetonka, MN) launched a new trait in corn, Syngenta Enogen Feed corn (SYT-EFC), to contain a thermotolerant α-amylase enzyme that becomes activated by increased temperatures intended for the dry milling ethanol process (Farm Journal, Inc., 2018). Including the enzyme within the corn grain eliminates the need for exogenous α-amylase to convert starch to sugar prior to ethanol fermentation. In 2016, SYT-EFC was first available as a starch source for cattle diets (Farm Journal, Inc., 2018). Two experiments have evaluated in vitro and in vivo utilization of the SYT-EFC in finishing diets on digestion characteristics and animal performance. In vitro, starch disappearance was found to be increased from 1.60% to 1.99% which would indicate that starch digestibility and ruminal α-amylase activity may be improved, thus resulting in an increase in animal performance (Hu et al., 2010). However, when corn that was modified to contain α-amylase was fed in finishing diets at 10% or 20% of the diet DM as ground corn, no differences in animal performance or carcass characteristics were observed (Schoonmaker et al., 2014). No data have been reported for feeding SYT-EFC as the sole starch source in finishing cattle diets. Today, almost all feedlot cattle are fed some inclusion of corn milling byproducts such as distillers grains or corn gluten feed (Samuelson et al., 2016). With the potential for increased ruminal starch digestibility associated with SYT-EFC, this experiment was designed to evaluate SYT-EFC with diets that help control acidosis with corn gluten feed (Krehbiel et al., 1995) or diets with some low inclusion of distillers grains for protein. Therefore, the objectives of the two experiments were to evaluate feeding SYT-EFC containing an α-amylase enzyme trait alone or blended with commercially available corn grain in diets containing wet and dry milling byproducts on feedlot cattle performance and carcass characteristics. Our hypothesis was that feeding SYT-EFC would improve feed efficiency compared with corn grain without the amylase trait.

MATERIALS AND METHODS

All procedures involving animal care and management were approved by the University of Nebraska Lincoln's Institutional Animal Care and Use Committee.

Exp. 1

A 172-d finishing experiment was conducted utilizing 300 crossbred, calf-fed steers (initial BW = 298 ± 16 kg) to evaluate the impact of feeding SYT-EFC (Syngenta Seeds, LLC, Minnetonka, MN) containing the α-amylase enzyme trait. All corn containing the α-amylase enzyme trait, SYT-EFC, was provided by Syngenta Seeds LLC. The commercial corn (CON) was grown at the University of Nebraska–Lincoln's Eastern Nebraska Research and Extension Center (ENREC) near Mead, NE during the summer of 2012. Steers were received at the University of Nebraska–Lincoln's ENREC feedlot in October of 2012 and utilized from November 2012 to May 2013.

Initial processing included vaccination for the prevention of *Clostridium chauvoei*, *septicum*, *novyi*, *sordellii, perfringens* Types C and D, and *Haemophilus somnus* (Vision 7 Somnus; Merck Animal Health, Summit, NJ) and a modified live virus vaccine for the prevention of IBR, BVD Type 2, BRSV, and as an aid in the control of BVD Type 1 and PI-3 (Vista-5; Merck Animal Health). After 60 d, cattle were revaccinated with a modified live virus vaccine for the prevention of IBR, BVD Type 2, BRSV, and as an aid in the control of BVD Type 1 and PI-3 (Vista-5; Merck Animal Health) and topically poured with an insecticide to kill flies, fleas, lice, mites, ticks, and deer ticks (Permectrin CD; Boehringer Ingelheim Vetmedica, Inc., Saint Joseph, MO). Steers were implanted with Revalor-XS (200 mg of trenbolone acetate and 40 mg estradiol; Merck Animal Health) on day 1.

All steers were limit fed a diet consisting of 32% alfalfa hay, 32% corn wet distillers grains plus solubles, 32% dry-rolled corn, and 4% supplement (DM basis) for 5 d at 2% of BW prior to the initiation of the trial in an effort to reduce variation in gut fill at the time of weighing (Watson et al., 2013). Steers were individually weighed using a hydraulic squeeze chute with load cells mounted on the chute (Silencer, Moly Manufacturing Inc., Lorraine, KS: scale readability ± 0.45 kg) for two consecutive days (0 and 1) after the limit feeding period for initial BW determination (Watson et al., 2013). Based on initial BW, steers were blocked by BW into light, medium, and heavy blocks (*n* = 3, 2, and 1 pen replicates, respectively), stratified by BW within each block, and assigned randomly to 1 of 30 pens. Pens were assigned randomly to 1 of 5 dietary treatments with a total of 10 steers per pen and 6 pens per treatment.

Dietary treatments were designed as a 2 × 2 + 1–factorial arrangement (Table 1). Treatments were designed as a 2 × 2 + 1–factorial arrangement with factors consisting of 1) corn type (SYT-EFC or conventional [CON]) and 2) byproduct type (with or without Sweet Bran [SB; Cargill Wet Milling, Blair, NE]) or a BLEND of STY-EFC and CON without SB. Treatment diets contained SB at 25% inclusion (DM basis) as a means of subacute acidosis control and as a protein source. Decreasing a proportion of excessively fermentable starch with a highly digestible fiber source, such as SB, has been shown to

Table 1. Dietary treatments evaluating SYT-EFC and conventional commercial corn with or without Sweet Bran (Exp. 1)

	Modified distillers grains plus solubles			Sweet Bran	
Ingredient, % DM	CON[a]	SYT-EFC[b]	BLEND	CON[a]	SYT-EFC[b]
Conventional dry-rolled corn	68.0	–	34.0	58.0	–
SYT-EFC[b] Dry Rolled Corn	–	68.0	34.0	–	58.0
Sweet Bran	–	–	–	25.0	25.0
MDGS[c]	15.0	15.0	15.0	–	–
Corn silage	12.0	12.0	12.0	12.0	12.0
Meal supplement[d]	5.0	5.0	5.0	5.0	5.0
Fine ground corn	2.174	2.174	2.174	2.435	2.435
Limestone	1.6	1.6	1.6	1.6	1.6
Urea	0.6	0.6	0.6	0.4	0.4
Salt	0.3	0.3	0.3	0.3	0.3
Tallow	0.125	0.125	0.125	0.125	0.125
Trace mineral premix	0.05	0.05	0.05	0.05	0.05
Potassium chloride	0.02	0.02	0.02	–	–
Rumensin-90	0.0165	0.0165	0.0165	0.0165	0.0165
Vitamin ADE premix	0.015	0.015	0.015	0.015	0.015
Tylan-40	0.01	0.01	0.01	0.01	0.01
Nutrient composition, %					
Starch	52.48	52.55	52.52	47.75	47.81
NDF	15.91	15.16	15.54	18.80	18.16
CP	14.15	14.22	14.18	13.45	13.51
Fat	4.07	4.01	4.04	3.19	3.13
Ca	0.63	0.67	0.65	0.61	0.64
K	0.58	0.59	0.59	0.67	0.68
P	0.40	0.39	0.39	0.46	0.44
Mg	0.20	0.20	0.20	0.23	0.23
S	0.16	0.15	0.16	0.19	0.18

[a] CON, commercially available corn grain without the α-amylase enzyme trait.

[b] Syngenta Enogen Feed Corn provided by Syngenta under identity-preserved procedures. Stored, processed, and fed separately.

[c] MDGS, modified distillers grains plus solubles.

[d] Supplement included 372.6 mg/kg Rumensin and 99.2 mg/kg Tylan.

reduce the length of time that cattle are exposed to an incidence of acidosis (Krehbiel et al., 1995). Treatment diets that did not contain SB contained corn-modified distillers grains plus solubles (MDGS, Green Plains Renewable Energy, Central City, NE) at 15% inclusion (DM basis) as a source of protein. Steers were adapted to the finishing diets over a 21-d period with 10% corn replacing 10% alfalfa hay, whereas inclusion of corn silage, corn-modified distillers grain plus solubles, and supplement remained the same in all diets at 12%, 15%, and 5%, respectively. In diets containing SB, corn replaced alfalfa hay with inclusion of SB, corn silage, and supplement remaining constant at 25%, 12%, and 5%, respectively. All supplements were formulated to include 33.0 mg/kg of monensin (DM basis, Elanco Animal Health), 9.0 mg/kg of tylosin (Elanco Animal Health), and to meet or exceed MP requirements (NRC, 1996).

Cattle were fed once daily at approximately 0800 and managed for ad libitum feed intake. Approximately once a week or when needed, refused feed was removed from feed bunks, weighed, and dried in a forced-air oven at 60°C (model LBB2-21-1; Despatch Industries, Minneapolis, MN) for 48 h (AOAC, 1999; method 4.1.03) to determine DM for accurate DMI. Ingredient samples were collected weekly, composited by month, and sent to a commercial laboratory (Servi-Tech Laboratories, Hastings, NE) to be analyzed for total starch (Megazyme International, 2011), CP (AOAC International, 2000; Method 990.03), NDF (ANKOM, 2006), ether extract (AOAC International, 2006; Method 2003.6), and minerals (Ca, P, S, K, and Mg; Mills and Jones, 1996).

On day 173, feed was offered at 50% of the previous day's DMI and cattle were pen weighed at 1600 h to determine final live BW. A 4% pencil shrink was applied to the final live BW to calculate dressing percentage. After pen weights were collected, cattle were loaded onto a semitractor trailer, hauled 57 miles to Omaha, NE, and harvested the morning of day 174 at a commercial abattoir (Greater Omaha, Omaha, NE). Hot carcass weights (HCW) and liver abscesses were recorded at the time of slaughter. Fat thickness, LM area, and USDA marbling score were recorded after a 48-h chill. Final BW, ADG, and G:F were calculated using HCW and adjusted to a common dressing percentage of 63%. Yield grade was calculated using the USDA YG equation: YG = 2.5 + (6.25 × 12th rib fat thickness, cm) − (2.06 × LM area, cm^2) + (0.2 × KPH fat, %) + (0.0017 × HCW, kg) (Boggs and Merkel, 1993).

Dietary treatment energy values were calculated utilizing pen performance data in the Galyean (2017) Net Energy Calculator utilizing shrunk initial BW, shrunk final BW, DMI, ADG, and a target endpoint (assume choice quality grade) to calculate net energy of maintenance and gain. The feeding values or improvements in G:F for treatments were calculated utilizing the following formula: (G:F treatment − G:F CON)/G:F CON. The improvements in G:F based on corn grain inclusion were then calculated using the previous formula divided by the corn grain inclusion of the diet (DM basis). Performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS Institute Inc., Cary, NC). Initial BW block was included as a fixed effect and pen served as the experimental unit. The model included the effects of SB, corn trait, the SB x corn trait interaction, and block. Data were also analyzed for treatments not containing SB (SYT-EFC, BLEND, and CON) as a randomized block design using a protected *F*-test. Liver abscess incidence data were analyzed using the GLIMMIX procedure of SAS as binomial variables with the number of animals affected by liver abscesses divided by the total number of animals within the pen. Probabilities less than or equal to α ($P \leq 0.05$) were considered significant, with tendencies acknowledged at *P*-values between 0.05 and 0.10.

Exp. 2

Two hundred forty crossbred steers (initial BW = 288 ± 15.4 kg) were utilized in a feedlot finishing trial at the University of Nebraska–Lincoln's Panhandle Research and Extension Center (PHREC) feedlot near Scottsbluff, NE. The experiment was conducted to evaluate the impact of feeding SYT-EFC corn, alone, blended with commercially available corn grain, or feeding commercially available corn and an α-amylase enzyme supplement on feedlot performance and carcass characteristics. Syngenta Enogen Feed Corn was provided by Syngenta Seeds, LLC (Minnetonka, MN) and all commercial corn was procured from a commercial grain elevator. Steers were received and utilized at the University of Nebraska–Lincoln's PHREC during the same time frame as Exp. 1.

Two weeks prior to the initiation of the experiment, steers were vaccinated for prevention of *Clostridium chauvoei*, *septicum*, *novyi*, *sordellii, perfringens* Types C and D, and *Haemophilus somnus* (Vision 7; Merck Animal Health, Summit, NJ), for the prevention of IBR, BVD Type 1 and II, PI-3, BRSV (Bovi-Shield Gold; Zoetis, Florham Park, NJ) and treated for internal and external parasites (Ivomex; Merial, Duluth, GA).

Cattle limit feeding, initial BW protocols, implanting, and grain adaptation procedures were the same as Exp. 1. Based on day 0 BW, steers were blocked into light, medium, or heavy BW blocks (*n* = 3, 2, and 1 pen replicates, respectively), stratified by BW and assigned randomly to 1 of 24 pens. Pens were assigned randomly to 1 of 4 dietary treatments with 10 head per pen and 6 replications per treatment. Dietary treatments included 1) SYT-EFC, 2) commercial corn (CON), 3) 50:50 blend of SYT-EFC and commercial corn (BLEND), and 4) commercial corn with an α-amylase enzyme supplement (Amaize; Alltech, Inc., Nicholasville, KY) added to the diet at a rate of 5 g/steer daily (CON-E; Table 2). The inclusion rate of 5 g/steer was based on manufacturer recommendations.

Steers that were blocked into the heavy, medium, and light BW blocks were harvested at a commercial abattoir (Cargill Meat Solutions, Fort Morgan, CO) on days 148, 169, and 181, respectively. On the final day, steers were withheld from feed and weighed at 0800 h before being shipped and slaughtered on the same day. Carcass data collection procedures and calculation of final BW were the same as Exp. 1.

Dietary treatment energy values were calculated utilizing pen performance data in the Galyean (2017) Net Energy Calculator similar to Exp. 1. The calculations for improvements in treatment G:F were similar to Exp. 1. Animal performance and carcass data were analyzed using the MIXED procedure of SAS as a randomized block design with pen as the experimental unit. The model included block and dietary treatment. Treatments were evaluated using a protected *F*-test and mean separation when significant variation was observed due to treatment. Liver abscess incidence data were analyzed using the GLIMMIX procedure of SAS as binomial variables with the number of animals affected by liver abscesses divided by the total number of animals within the pen. Probabilities less than or equal to α ($P \le 0.05$) were considered significant, with tendencies acknowledged at *P*-values between 0.05 and 0.10.

RESULTS AND DISCUSSION

Exp. 1

Effects of corn trait by SB interaction on feedlot performance and carcass characteristics. A tendency for a corn trait x SB interaction ($P = 0.07$) for carcass-adjusted final BW was observed (Table 3). Cattle fed SYT-EFC with SB had numerically greater final BW than CON but not when cattle were fed diets without SB. Interactions were observed for ADG and G:F ($P = 0.05$ and 0.02, respectively). Steers that were

Table 2. Dietary treatments evaluating SYT-EFC and conventional corn with or without added enzyme (Exp. 2)

Ingredient	CON[a]	SYT-EFC[b]	BLEND	CON-E[c]
Conventional dry-rolled corn	64.0	–	32.0	64.0
SYT-EFC[b] dry-rolled corn	–	64.0	32.0	–
WDGS	15.0	15.0	15.0	15.0
Corn silage	15.0	15.0	15.0	15.0
Liquid supplement[d,e]	6.0	6.0	6.0	6.0
Nutrient composition, %				
Starch	51.40	52.23	51.82	51.41
NDF	15.46	15.66	15.56	15.46
CP	12.96	13.41	13.18	12.96
Fat	3.44	3.89	3.67	3.44
Ca	0.60	0.60	0.60	0.60
K	0.55	0.53	0.54	0.55
P	0.34	0.31	0.32	0.34
Mg	0.15	0.15	0.15	0.15
S	0.15	0.15	0.15	0.15

[a] CON, commercially available corn grain without the α-amylase enzyme trait.

[b] Sygenta Enogen Feed Corn provided by Syngenta under identity-preserved procedures. Stored, processed, and fed separately.

[c] CON-E, conventional corn with enzyme supplement (Amaize; Alltech, Inc.) added to the diet at a rate of 5 g/steer daily.

[d] Liquid supplement contained 0.6% urea, 1.6% Ca, 0.3% salt, 0.02% potassium chloride, vitamins, and trace minerals.

[e] Supplement included 372.6 mg/kg Rumensin and 99.2 mg/kg Tylan.

Table 3. Effect of corn hybrid and inclusion of Sweet Bran on finishing steers performance and carcass characteristics (Exp. 1)

	Dietary treatments					*P*-Value*				
	0% Sweet Bran			25% Sweet Bran						
	CON[†]	SYT-EFC[†]	BLEND	CON[†]	SYT-EFC[†]	SEM	Trait	SB	Trait*SB	*F*-test[‡]
Animal performance										
Initial BW, kg	304	305	305	305	305	0.38	0.09	0.13	0.51	0.35
Final BW, kg[‖]	587	585	591	580	597	5.12	0.14	0.68	0.07	0.74
Final Live BW, kg	590	587	592	581	596	5.01	0.17	0.98	0.08	0.87
DMI, kg/d	10.4	10.1	10.4	10.6	10.3	0.14	0.07	0.36	0.99	0.35
ADG, kg[‖]	1.64^{ab}	1.62^{ab}	1.65	1.58^{b}	1.69^{a}	0.03	0.15	0.74	0.05	0.66
G:F[3]	0.158^{bc}	0.160^{ab}	0.159	0.149^{c}	0.164^{a}	0.002	<0.01	0.68	0.02	0.67
Energy values[$]										
NEm, Mcal/kg	1.91^{a}	1.94^{a}	1.93	1.84^{b}	1.96^{a}	0.02	< 0.01	0.34	0.04	0.72
NEg, Mcal/kg	1.27^{a}	1.29^{a}	1.28	1.20^{b}	1.31^{a}	0.02	< 0.01	0.32	0.05	0.67
Carcass characteristics										
HCW, kg	370	369	373	365	376	3.23	0.14	0.72	0.07	0.68
Dressing %	62.7	62.8	62.9	62.8	63.1	0.20	0.48	0.39	0.79	0.63
Marbling score[¶]	456	484	511	443	488	10.7	< 0.01	0.68	0.43	0.13
12th-Rib fat thickness, cm	1.22^{z}	1.42^{y}	1.45^{y}	1.22	1.35	0.05	0.01	0.56	0.41	0.03
LM Area, cm^2	83.2	80.6	79.4	82.6	83.9	1.24	0.53	0.34	0.20	0.10
Calculated yield grade[¶]	3.18^{z}	3.48^{y}	3.60^{y}	3.17	3.33	0.10	0.03	0.46	0.45	0.02
Liver abscesses, %	8.96	5.63	5.37	11.12	5.63	--	0.23	0.77	0.77	0.73

*Trait, *P*-value for the main effect of corn trait; SB, *P*-value for the main effect of Sweet Bran inclusion; Trait*SB, *P*-value for the interaction between corn trait and Sweet Bran inclusion.

[†] CON, commercially available corn grain without the α-amylase enzyme trait; SYT-EFC, Syngenta Enogen Feed Corn with the α-amylase enzyme trait.

[‡] Calculated from HCW adjusted to a common 63% pressing percentage.

[‖] Values calculated by pen using the 1996 NRC equations.

[$] Marbling Score: 400 = Small^{00}.

[¶] Calculated as 2.5 + (6.35 × 12th-rib fat, cm) + (0.2[KPH, %]) + (0.0017 × HCW, kg) − (2.06 × LM area, cm^2).

^{a,b,c}Means within a row with unlike superscripts differ ($P < 0.05$) for the 2 × 2 factorial interaction.

^{y,z}Means within a row with unlike superscripts differ ($P < 0.05$) for the three treatments within 0% Sweet Bran.

fed SYT-EFC with SB had greater ADG ($P \leq 0.05$) and G:F ($P \leq 0.05$) than CON resulting in a 10.1% dietary improvement in G:F. However, when based on a corn grain inclusion of 58%, there was a 17.4% increase due to grain difference. Cattle fed diets without SB resulted in no difference between SYT-EFC and CON ($P \geq 0.44$) which lead to an interaction. The numerical improvement in G:F due to treatment was only 1.3% instead of 10.1% observed in diets with SB. A corn trait × SB interaction was observed for NE_m ($P = 0.04$) and NE_g ($P = 0.05$) values. Based on cattle performance, steers fed SYT-EFC with SB had greater ($P < 0.01$) NE_m and NE_g values compared with CON, whereas there was no difference ($P \geq 0.41$) for NEm or NEg between cattle fed SYT-EFC and CON without SB. The increased response observed for SYT-EFC when fed with SB resulted in a 6.5% and 9.2% increase in NEm and NEg compared with CON. No interaction was observed for DMI ($P = 0.99$). Steers consuming SYT-EFC tended ($P = 0.07$) to consume less DM compared with CON.

HCW followed the same trend ($P = 0.07$) as final BW (Table 3) with the magnitude of difference being greater for steers fed SB-based diets compared with CON-based diets. There were no interactions for the remaining carcass characteristics ($P \geq 0.20$). For the main effect of trait, marbling scores, 12th-rib fat thickness, and calculated yield grade were greater ($P \leq 0.03$) for cattle fed SYT-EFC compared with CON (Table 3). The increase in marbling score for the steers fed SYT-EFC could be attributed to an increase in glucose being absorbed by the small intestine and utilized by the animal. Smith et al. (2009) reported that glucose contributes a greater proportion of acetyl units to lipid synthesis in intramuscular adipose tissue compared with subcutaneous adipose tissue. In intramuscular adipose tissue, glucose accounted for approximately 62% of the acetyl units to fatty acid biosynthesis, whereas acetate contributed to less than 20% (Smith and Crouse, 1984). The addition of supplemental exogenous α-amylase has been reported to increase (Tricarico et al., 2007) or have little effect (Tricarico et al., 2007) on 12th-rib fat thickness. However, feeding α-amylase does have the potential to manipulate fat partitioning in cattle by altering ruminal VFA production. It has been reported that α-amylase supplementation in finishing steers has reduced the molar proportion of propionate, thus increasing the acetate to propionate ratio (Tricarico et al., 2005). Similarly, Rojo et al. (2005) reported a quadratic reduction in propionate when amylase was supplemented at 1.45 g/kg DM of sorghum compared with 2.90 g/kg DM of sorghum when fed to lambs. DeFrain et al. (2005) reported a decrease in propionate and an increase in acetate to propionate ratio in cows fed supplemental α-amylase compared with controls. In subcutaneous adipose tissue, acetate contributed to 70% of the acetyl units to fatty acid biosynthesis, whereas glucose accounted for less than 5% (Smith and Crouse, 1984) which helps explain that the increase in calculated yield grade can be attributed to the increase in 12th-rib fat thickness.

Effects of SYT-EFC fed without SB on feedlot performance and carcass characteristics. No differences ($P \geq 0.35$) between CON, SYT-EFC, and BLEND were observed for final BW, DMI, ADG, G:F, NEm, or NEg when fed with MDGS (Table 3). Similarly, Schoonmaker et al. (2014) observed no differences in final BW, DMI, ADG, and G:F when steers were fed 0%, 10%, or 20% of the diet DM of CA3272 corn with 20% wet distillers grains plus solubles. In finishing diets containing supplemental α-amylase, an increase in ADG (Burroughs et al. 1960; Tricarico et al., 2007) or no difference in all performance characteristics (DMI, ADG, or G:F; Tricarico et al., 2007; DiLorenzo et al., 2011) was observed.

HCW, dressing %, marbling score, LM area, and incidence of liver abscesses were not influenced ($P \geq 0.12$) by dietary treatment (Table 3). However, cattle fed BLEND had greater marbling scores than CON ($P = 0.05$). Fat depth was greater ($P = 0.03$) for steers fed SYT-EFC and BLEND compared with the CON. This agrees with the notion that glucose contributes a greater proportion of acetyl units to lipid synthesis in intramuscular adipose tissue and that feeding α-amylase can have the potential to alter fat partitioning in cattle by changing ruminal VFA production (Smith et al., 2009). Calculated yield grade was also greater ($P = 0.02$) for steers fed SYT-EFC and BLEND compared with CON corn. However, Schoonmaker et al. (2014) reported no differences for all carcass parameters when steers were fed 0%, 10%, or 20% of the diet DM with 20% WDGS.

Exp. 2

Dry matter intakes were not different ($P = 0.80$) among all four treatments (Table 4). Final BW and ADG were greater ($P < 0.01$) for steers fed SYT-EFC, BLEND, and CON-E compared with CON. Similarly, G:F was improved ($P < 0.01$) for steers fed SYT-EFC, BLEND, and CON-E compared with CON. When comparing feed efficiencies of steers fed SYT-EFC with CON, there was a 5.7% difference due to diet. When accounting for the corn grain inclusion (64%, DM basis), an improvement of 8.9% was observed presumably due to corn differences. Similar improvements in feed efficiency were observed for steers fed BLEND and CON-E. Based on cattle performance, diets containing the amylase treatments resulted in greater NEm and NEg than the CON ($P < 0.01$ and $P < 0.01$, respectively) when fed to steers. The NEm values (2.01, 2.03, and 2.04 Mcal.kg for SYT-EFC, BLEND, and CON-E, respectively) were increased by 4.1%, 5.2%, and 5.7%, respectively, compared with CON. The NEg values (1.36, 1.37, and 1.38 Mcal.kg for SYT-EFC, BLEND, and CON-E, respectively) were increased by 6.3%, 7.0%, and 7.8%, respectively, compared with CON. Previous research of feeding supplemental α-amylase in feedlot finishing diets has not been consistent. The literature has shown a 6.5% to 11.9% increase in ADG (Burroughs et al., 1960; Tricarico et al., 2007) or no difference in all performance characteristics (DMI, ADG, or G:F; Tricarico et al., 2007; DiLorenzo et al., 2011) when supplemental α-amylase has been fed in finishing diets. Although not significant ($P = 0.55$) due to limited power, DiLorenzo et al. (2011) observed a 9.5% increase in G:F for steers fed supplemental amylase compared with the control. When corn containing supplemental α-amylase was fed in finishing diets at 0%, 10%, or 20% inclusion (DM basis), no differences in DMI, ADG, or G:F were observed ($P \geq 0.31$; Schoonmaker et al., 2014). When fed in dairy diets, supplemental α-amylase has been observed to increase milk yield compared with controls diets (Tricarico et al., 2005; Harrison and Tricarico, 2007; Klingerman et al., 2009) or a slight numerical improvement (DeFrain et al., 2005).

HCW were greater ($P < 0.01$) for SYT-EFC, BLEND, and CON-E compared with CON (Table 4). Similarly, Tricarico et al. (2007) reported

Table 4. Effect of corn hybrid and inclusion of an α-amylase enzyme supplement on finishing steer performance and carcass characteristics (Exp. 2)

	Dietary treatment[*]					
Item	CON	SYT-EFC	BLEND	CON-E	SEM	*F*-Test[†]
Animal performance						
Initial BW, kg	293	294	293	293	0.45	0.25
Final BW, kg[‡]	570^{b}	590^{a}	589^{a}	589^{a}	3.37	<0.01
Final Live BW, kg	573^{b}	589^{a}	587^{a}	588^{a}	2.57	<0.01
DMI, kg/d	10.7	10.8	10.7	10.6	0.14	0.72
ADG, kg[‡]	1.68^{b}	1.79^{a}	1.78^{a}	1.78^{a}	0.02	<0.01
G:F[‡]	0.157^{b}	0.166^{a}	0.168^{a}	0.168^{a}	0.002	<0.01
Energy values[‖]						
NEm, Mcal/kg	1.93^{b}	2.01^{a}	2.03^{a}	2.04^{a}	0.02	<0.01
NEg, Mcal/kg	1.28^{b}	1.36^{a}	1.37^{a}	1.38^{a}	0.02	<0.01
Carcass characteristics						
HCW, kg	359^{b}	372^{a}	371^{a}	371^{a}	2.14	<0.01
Dressing %	62.7	63.2	63.3	63.2	0.30	0.58
Marbling Score[$]	451	468	481	468	7.7	0.08
12th-Rib fat thickness, cm	1.44	1.52	1.55	1.52	0.04	0.26
LM area, cm^2	77.9^{b}	78.0^{b}	80.2^{a}	79.7^{a}	0.58	0.01
Calculated yield grade[¶]	3.47	3.64	3.55	3.55	0.07	0.35
Liver abscesses, %	3.33	5.08	0	5.17	–	0.41

[*] CON, commercially available corn grain without the α-amylase enzyme trait; SYT-EFC, Syngenta Enogen Feed Corn containing an α-amylase enzyme; BLEND, 50:50 blend of SYT-EFC and CON on a DM basis; CON-E, inclusion of a commercially available α-amylase enzyme supplement in CON-based diets.

[†] *F*-test, *F*-test statistic for the effect of treatment.

[‡] Calculated from HCW adjusted to a common 63% pressing percentage.

[‖] Values calculated by pen using the 1996 NRC equations.

[$] Marbling Score: 300 = Slight^{00}; 400 = Small^{00}.

[¶] Calculated as 2.5 + (6.35 × 12th-rib fat, cm) + (0.2[KPH, %]) + (0.0017 × HCW, kg) − (2.06 × LM area, cm^2).

[a,b] Means within a row with unlike superscripts differ ($P < 0.05$).

a quadratic increase ($P = 0.03$) in HCW in heifers fed supplemental α-amylase at 580 compared with the control, with no additional benefit at 1,160 DU/kg of DM. Marbling score tended ($P = 0.08$) to be greatest for BLEND, intermediate for SYT-EFC and CON-E, and least for CON. Longissimus muscle area was greater ($P = 0.03$) for BLEND and CON-E compared with SYT-EFC and CON. Tricarico et al. (2007) observed a quadratic increase ($P = 0.04$) in LM area in heifers fed supplemental α-amylase. Dressing percent, fat depth, calculated yield grade, and incidence of liver abscesses were not different ($P \geq 0.22$) among treatments.

Our results suggest that there is an improvement in feed efficiency when feeding SYT-EFC compared with conventional, control corn at both locations. There is potential for an increase in marbling score as it is an endproduct of additional glucose being utilized by the animal resulting in a greater proportion of acetyl units to lipid synthesis in intramuscular adipose tissue, which warrants additional research to examine the impact of feeding a modified corn containing α-amylase in finishing diets.

LITERATURE CITED

ANKOM. 2006. Ankom technology method 6. Neutral detergent fiber in feeds by filter bag technique. Macedon, NY: ANKOM Tech.

AOAC. 1999. Official method of analysis. 16th ed. Arlington, VA: Association of Official Analytical Chemists.

AOAC International. 2000. AOAC official method 990.3. protein (crude) in animal feed, combustion method, official methods of analysis of AOAC International, 17th ed. Dr. W. Horwitz, editor. Gaithersburg, MD: AOAC Int.

AOAC Internaitonal. 2006. AOAC official method 2003.6. crude fat in feeds, cereal grains, and forages (Modified for Extraction with Petroleum Ether). Gaithersburg, MD: Official Methods of Analysis of AOAC International. AOAC Int.

Beauchemin, K. A., L. M. Rode, and V. J. H. Sewalt. 1995. Fibrolytic enzymes increase fiber digestibility and growth rate of steers fed dry forages. Can. J. Anim. Sci. 75:641–644. doi:10.4141/cjas95-096

Boggs, D. L., and R. A. Merkel. 1993. Beef carcass evaluation, grading, and pricing. In: D. L. Boggs, R. A. Merkel editors. Live animal carcass evaluation and selection manual. Dubuque, IA: Kendel/Hunt Publishing Co.; p. 105–130. doi:10.2527/jas1960.192458x

Burroughs, W., W. Woods, S. A. Ewing, J. Greig, B. Theurer. 1960. Enzyme additions to fattening cattle rations. J. Anim. Sci. 19:458–464.

DeFrain, J. M., A. R. Hippen, K. F. Kalscheur, and J. M. Tricarico. 2005. Effects of dietary alpha-amylase on metabolism and performance of transition dairy cows. J. Dairy Sci. 88:4405–4413. doi:10.3168/jds.S0022-0302(05)73127-1

DiLorenzo, N., D. R. Smith, M. J. Quinn, M. L. May, C. H. Ponce, W. Steinberg, M. A. Engstrom, and M. L. Galyean. 2011. Effects of grain processing and supplementation with exogenous amylase on nutrient digestibility in feedlot diets. Livest. Sci. 137:178–184. doi:10.1016/j.livsci.2010.11.003

Farm Journal, Inc. (Producer). 2018. Improving profit potential through rations with more available energy [Video webinar]. http:fjwebinars.com/drovers/58 – accessed October 10, 2018.

Galyean, M. 2017. The Home Page of Michael Galyean. NEm and NEg Calculations. http://www.depts.ttu.edu/afs/home/mgalyean/ – accessed January 9, 2018.

Hale, W. H. 1973. Influence of processing on the utilization of grains (starch) by ruminants. J. Anim. Sci. 37:1075–1080. doi:10.2527/jas1973.3741075x

Harrison, G. A., and J. M. Tricarico. 2007. Effects of an *Aspergillus oryzae* extract containing α-amylase activity on lactational performance in commercial dairy herds. Prof. Anim. Scient. 23:291–294. doi:10.15232/S1080-7446(15)30976-1

Hu, W., M. E. Persia, and L. Kung, Jr. 2010. Short communication: in vitro ruminal fermentability of a modified corn cultivar expressing a thermotolerant α-amylase. J. Dairy Sci. 93:4846–4849. doi:10.3168/jds.2009-2321

Huck, G. L., K. K. Kreikemeier, G. L. Kuhl, T. P. Eck, and K. K. Bolsen. 1998. Effects of feeding combinations of steam-flaked grain sorghum and steam-flaked, high-moisture, or dry-rolled corn on growth performance and carcass characteristics in feedlot cattle. J. Anim. Sci. 76:2984–2990. doi:10.2527/1998.76122984x

Jaeger, S. L., M. K. Luebbe, C. N. Macken, G. E. Erickson, T. J. Klopfenstein, W. A. Fithian, and D. S. Jackson. 2006. Influence of corn hybrid traits on digestibility and the efficiency of gain in feedlot cattle. J. Anim. Sci. 84:1790–1800. doi:10.2527/jas.2005-570

Klingerman, C. M., W. Hu, E. E. McDonell, M. C. DerBedrosian, and L. Kung, Jr. 2009. An evaluation of exogenous enzymes with amylolytic activity for dairy cows. J. Dairy Sci. 92:1050–1059. doi:10.3168/jds.2008-1339

Krehbiel, C. R., R. A. Stock, D. W. Herold, D. H. Shain, G. A. Ham, and J. E. Carulla. 1995. Feeding wet corn gluten feed to reduce subacute acidosis in cattle. J. Anim. Sci. 73:2931–2939. doi:10.2527/1995.73102931x

Luebbe, M. K., G. E. Erickson, T. J. Klopfenstein, and W. A. Fithian. 2009. Influence of corn hybrid traits and processing method on nutrient digestibility. Prof. Anim. Scient. 25:496–509. doi:10.15232/S1080-7446(15)30737-3

Megazyme International. 2011. Total starch assay procedure. Wicklow, Ireland: AOAC Official Method 996.11. AACC Method 76.13. Bray Business Park, Bray, Co.

Mills, H. A., and J. B. Jones. 1996. Plant Analysis Handbook II: A practical sampling, Preparation, analysis, and interpretation guide. Athens, GA: Micromacro Publishing, Inc, p. 122 (Table 5.3).

National Research Council. 1996. Nutrient requirements of beef cattle. 7th ed.Washington, D.C: National Academy Press.

Owens, F. N., D. S. Secrist, W. J. Hill, and D. R. Gill. 1997. The effect of grain source and grain processing on performance of feedlot cattle: a review. J. Anim. Sci. 75:868–879. doi:10.2527/1997.753868x

Owens, F. N., D. S. Secrist, W. J. Hill, and D. R. Gill. 1998. Acidosis in cattle: a review. J. Anim. Sci. 76:275–286. doi:10.2527/1998.761275x

Rojo, R., G. D. Mendoza, S. S. González, L. Landois, R. Bárcena, M. M. Crosby. 2005. Effects of exogenous amylases from *Bacillus licheniformis* and *Aspergillus niger* on ruminal starch digestion and lamb performance. J. Anim. Feed Sci. 123–124:655–665. doi:10.1016/j.anifeedsci.2005.04.053

Samuelson, K. L., M. E. Hubbert, M. L. Galyean, and C. A. Loest. 2016. Nutritional recommendations of feedlot consulting nutritionists: the 2015 New Mexico State and Texas Tech University survey. J. Anim. Sci. 94:2648–2663. doi:10.2527/jas.2016-0282

Schoonmaker, J. P., M. E. Persia, and D. C. Beitz. 2014. Effect of feeding corn modified to contain a unique amylase on performance and carcass characteristics of feedlot steers. Prof. Anim. Scient. 30:561–565. doi:10.15232/pas.2014-01322

Smith, S. B., and J. D. Crouse. 1984. Relative contributions of acetate, lactate and glucose to lipogenesis in bovine intramuscular and subcutaneous adipose tissue. J. Nutr. 114:792–800. doi:10.1093/jn/114.4.792

Smith, S. B., H. Kawachi, C. B. Choi, C. W. Choi, G. Wu, and J. E. Sawyer. 2009. Cellular regulation of bovine intramuscular adipose tissue development and composition. J. Anim. Sci. 87(14 Suppl):E72–E82. doi:10.2527/jas.2008-1340

Tricarico, J. M., M. D. Abney, M. L. Galyean, J. D. Rivera, K. C. Hanson, K. R. McLeod, and D. L. Harmon. 2007. Effects of a dietary aspergillus oryzae extract containing alpha-amylase activity on performance and carcass characteristics of finishing beef cattle. J. Anim. Sci. 85:802–811. doi:10.2527/jas.2006-427

Tricarico, J. M., J. D. Johnston, K. A. Dawson, K. C. Hanson, K. R. McLeod, and D. L. Harmon. 2005. The effect of an *Aspergillus oryzae* extract containing alpha-amylase activity on ruminal fermentation and milk production in lactating Holstein cows. Anim. Sci. 81:365–374. doi:10.1079/ASC50410365

Vasconcelos, J. T., and M. L. Galyean. 2007. Nutritional recommendations of feedlot consulting nutritionists: the 2007 texas tech university survey. J. Anim. Sci. 85:2772–2781. doi:10.2527/jas.2007-0261

Watson, A. K., B. L. Nuttelman, T. J. Klopfenstein, L. W. Lomas, and G. E. Erickson. 2013. Impacts of a limit-feeding procedure on variation and accuracy of cattle weights. J. Anim. Sci. 91:5507–5517. doi:10.2527/