Effects of diet and *Aspergillus oryzae* extract or *Saccharomyces cervisiae* on growth and carcass characteristics of lambs and steers fed to meet requirements of natural markets

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Effects of diet and *Aspergillus oryzae* extract or *Saccharomyces cervisiae* on growth and carcass characteristics of lambs and steers fed to meet requirements of natural markets[1,2]

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ABSTRACT: Two studies were conducted to determine the effects of diet and feed additive on growth and carcass characteristics of lambs and cattle destined for all natural markets. In Exp. 1, 48 Dorset × Hampshire lambs (initial BW 29.4 ± 0.1 kg) were used in a randomized complete block experiment to determine the effects of *Aspergillus oryzae* extract, Amaferm (AMF) supplementation (1 g/d) in an 85% concentrate diet on growth and carcass characteristics. Lambs were allotted to 12 pens (4 lambs per pen), and blocked by sex and BW. Lambs were fed until the average BW of each pen reached a target BW (55.4 kg for wethers and 50.0 kg for ewes), at which time the entire pen of lambs was slaughtered. Amaferm resulted in a greater ($P = 0.07$) G:F. In Exp. 2, 168 crossbred steers (initial BW 300 ± 0.7 kg) were used in a trial with a 3 × 2 factorial arrangement of treatments to examine the effects of 0.5 g/d of *Saccaromyces cervisiae boulardii* CNCM 1079-Levucell SB (LEV), or 3 g/d of AMF with 2 corn sources, dry whole-shelled corn or high moisture corn, on growth and carcass characteristics. Neither LEV nor AMF improved ($P > 0.10$) carcass characteristics compared with control or non-feed-supplemented steers. Addition of LEV to high-concentrate, corn-based diets did not improve ($P > 0.10$) growth performance of feedlot steers. However, addition of AMF to a diet composed of dry whole-shelled corn resulted in an improvement ($P < 0.05$) in G:F (0.208 vs. 0.194). Results indicate that at the amounts fed, AMF may improve G:F for lambs and steers fed dry corn-based finishing diets.

Key words: all natural, Amaferm, beef, efficiency, lamb, Levucell SB

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INTRODUCTION

In conventional beef feedlot systems, feed-grade antibiotics are used to reduce metabolic disorders, improve feed efficiency, and reduce ruminal acidosis. The development of natural markets not allowing feed grade antibiotics or ionophores has created a need for nonantibiotic products capable of reducing acidosis and improving feed efficiency. Amaferm (**AMF**; Biozyme Inc., St. Joseph, MO), a patented fermentation extract of the mold *Aspergillus oryzae*, increases lactate utilization in the rumen by the lactate-utilizing bacteria *Megasphaera elsdenii* and *Selenomonas ruminantium* (Nisbet and Martin, 1990; Waldrip and Martin, 1993; Beharka and Nagaraja, 1998), which may hinder the postfeeding decline in ruminal pH (Nisbet and Martin, 1990; Waldrip and Martin, 1993). Levucell SB (**LEV**; Lallemand Nutrition, Blagnac, France) is a probiotic containing the CNCM I-1079 strain of *Saccharomyces cervisiae*, ssp. *boulardii* that has been found to stimulate rumen microbial metabolism (Oeztuerk et al., 2005), and may enhance the immune response of stressed cattle (Keyser et al., 2007). *Saccharomyces cerevisiae* CNCM-1077 has been shown to increase ruminal pH, decrease time spent under pH 5.6 (Thrune et al., 2009), decrease ruminal lactate concentration (Guedes et al., 2008), and increase ruminal propionate concentrations (Pinos-Rodríguez et al., 2008).

Previous research has not looked specifically at the effects of AMF or LEV on animal performance and carcass characteristics in high-concentrate feedlot diets. The hypothesis was that products allowable for all natural markets, which have been shown to stimulate microbial metabolism and alleviate metabolic stressors,

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may improve the performance of ruminants fed corn-based diets. Thus, the objective of these studies was to examine the effects of a fungal-derived prebiotic and a yeast containing probiotic in corn-based feedlot diets on growth performance and carcass characteristics of feedlot lambs and cattle.

MATERIALS AND METHODS

The Agricultural Animal Care and Use Committee of The Ohio State University approved the procedures used in these experiments.

Exp. 1

Forty-eight Dorset × Hampshire lambs (initial BW = 29.4 ± 0.1 kg) were used in a randomized complete block experiment to determine the effects of AMF in a diet containing a large proportion of corn on animal performance and carcass characteristics. Lambs were housed at the Ohio Agriculture Research and Development Center's sheep research feedlot in Wooster, OH. All pens were constructed using expanded metal floors with metal gates on 3 sides and a wooden fence line feed bunk on the fourth side. Pens were 1.49 × 4.88 m with 1.49 m of bunk space. Each pen had an automatic water cup so that water was available at all times. Animals were allotted to pen based on sex (wethers = 24 and ewes = 24) and initial BW (light, medium, or heavy). A total of 12 pens were used in the experiment, and each pen contained 4 lambs. Lambs were individually weighed, ear tagged, and vaccinated against internal and external parasites with injectable Ivermectin (Merial, Duluth, GA). Initial and final BW of the lambs was determined using the average of BW taken on 2 consecutive days, before feeding.

Diets were formulated to meet, or exceed, the dietary nutrient requirements for lambs (NRC, 1985; Table 1). Feed samples were collected every week throughout the trial and were analyzed for DM according to the procedures of Goering and Van Soest (1970). Neutral detergent fiber content of feed was determined according to the procedures of Van Soest et al. (1991). Nitrogen content of feed was determined by macro-Kjeldahl analysis (AOAC, 1984).

During the first 2 wk, feed intake was restricted to 3.5% of BW, based on the average BW within a pen, to allow animals to adapt to the change in diet and to prevent the occurrence of digestive disorders. After the 2-wk adaptation period, lambs were offered feed for ad libitum intake for the remainder of the experiment. The diet contained ground corn, alfalfa, soybean hulls, and soybean meal to provide 2.0 Mcal of NE_m/kg and 1.4 Mcal of NE_g/kg of DM. Amaferm was provided at either 0 or 1 g·animal^{-1}·d^{-1}. A pelleted premix of 97.8% dry, ground corn and 2.2% AMF was mixed with the pelleted diet, daily, for pens receiving AMF, at the rate of 45.4 g·animal^{-1}·d^{-1}, to allow AMF to be supplemented at 1.0 g·animal^{-1}·d^{-1}. Pens of lambs fed the control diet, without AMF, were fed pelleted dry, ground corn at the rate of 45.4 g·animal^{-1}·d^{-1}, mixed with the pelleted diet. All feed was in pelleted form, including the AMF supplement. Feed offered and refused was weighed daily in each pen before refeeding at 0830 h. Because sorting was expected, feed was not allowed to remain in the feed bunk for more than 1 d before being discarded. Pens of lambs never had feed offered increased or decreased by more than 10% of the intake of the previous day.

Initial and final BW were calculated as the average of BW taken on 2 consecutive days at the start and end of the trial, and interim BW were taken every 14 d. All BW were taken before feeding at 0830 h. Average daily gain, DMI, G:F (kg of BW gain/kg of feed), and days required to reach slaughter weight were determined for all lambs. Lambs were removed from the trial, on a pen basis, as each pen reached the predetermined market range of 49.9 to 54.4 kg of BW for ewes and 54.4 to 59.0 kg of BW for wethers.

Once the average BW of lambs in a pen reached the target market weight, lambs were transported to The Ohio State University Meat Science Laboratory in Columbus and slaughtered. Hot carcass weights were recorded immediately before chilling. Backfat thickness, body wall thickness, and LM area were measured between 12th and 13th rib after carcasses had been chilled for 48 h. Leg score, overall conformation score, lean color score, marbling score, and USDA quality grade

Table 1. Diet and nutrient composition in Exp. 1

Item	Diet[1]
Ingredient, % (DM basis)	
Ground corn	68.79
Soybean hulls	9.60
Soybean meal	7.57
Corn gluten meal	6.87
Dried, ground alfalfa	4.75
Limestone	0.79
Urea	0.70
Trace mineral salt[2]	0.44
Ammonium chloride	0.35
Selenium, 201 mg/kg	0.08
Vitamin A, 30,000 IU/kg	0.01
Vitamin D, 3,000 IU/kg	0.01
Vitamin E, 44,000 IU/kg	0.04
Analyzed nutrient composition	
CP, %	19.33
NDF, %	21.80
Calculated nutrient composition	
Potassium, %	0.69
Calcium, %	0.48
Phosphorus, %	0.36
Calculated NE_m,[3] Mcal/kg	2.04
Calculated NE_g,[3] Mcal/kg	1.39

[1]Amaferm (Biozyme Inc., St. Joseph, MO) was supplemented to provide 0 or 1 g·animal^{-1}·d^{-1}, and diets were fed in pelleted form.

[2]Contained >93% NaCl, 0.35% Zn, 0.28% Mn, 0.175% Fe, 0.035% Cu, 0.007% I, and 0.007% Co.

[3]Calculated according to NRC (1985) using book values multiplied by the percentage of each ingredient in the feed.

were subjectively determined for each carcass by an experienced evaluator 48 h after slaughter. The LM from the 11th to 12th rib was removed from the left side of each carcass, trimmed of external fat, ground, and then subsamples were taken for determination of moisture and ether-extractable lipid (AOAC, 1984).

The experiment was designed as a randomized complete block to evaluate factors associated with performance and carcass characteristics. Lambs were initially blocked by BW (light, medium, or heavy) and by sex (ewe or wether). Data were analyzed using the Mixed procedures (SAS Inst. Inc., Cary, NC) with pen as the experimental unit. Performance and carcass data were analyzed using a model that included sex, BW, and AMF supplementation (0 vs. 1 g). Additionally, final BW was included in the model as a covariate for carcass measurements. Treatment means were compared with Fisher's protected LSD using the PDIFF statement of SAS when protected by a significant ($P < 0.10$) *F*-value.

Exp. 2

The objectives were to determine effects of natural feed supplements on performance and carcass characteristics of cattle fed high-moisture corn (**HMC**) or dry whole-shelled corn (**DWSC**). One hundred sixty-eight crossbred beef steers (initial BW = 300 ± 0.7 kg) were used with a 3 × 2 factorial arrangement of treatments in a completely randomized design. Main effects were no feed supplement (**CON**), *S. cervisiae boulardii* CNCM 1079-Levucell SB, or AMF and 2 dietary energy sources differing in their rate of ruminal fermentation (HMC or DWSC). Cattle were fed a receiving diet composed of 30% corn silage, 30% soybean hulls, 10% DWSC, and 30% supplement on a DM basis. The receiving diet contained 19% CP on a DM basis. Diets were formulated to meet, or exceed, the dietary nutrient requirements for cattle (NRC, 1996). Feed samples were collected every week throughout the trial and were analyzed for DM according to the procedures of Goering and Van Soest (1970). Neutral detergent fiber content of feed was determined according to the procedures of Van Soest et al. (1991). Nitrogen content of feed was determined by macro-Kjeldahl analysis (AOAC, 1984). During the receiving period, no prebiotic or probiotic products were fed.

At the start of the finishing trial, cattle were fed 1 of 2 finishing diets: 1 formulated with DWSC as the main energy source and the other formulated with HMC as the main energy source (Table 2). High moisture corn and DWSC composed 76% of their diets, respectively, on a DM basis. Both the HMC and DWSC diets were fed whole; however, based on visual appraisal, approximately one-third of the HMC kernels were cracked during storage and diet mixing. Cattle were restricted fed during the first 2 wk of the trial to control feed intake during diet transition, but diets were offered for ad libitum intake for the remainder of the finishing period.

Cattle were randomly assigned to 1 of 24 pens in the study, with 7 animals per pen, and pens were randomly assigned to 1 of 6 dietary treatments. Cattle were allotted to pens such that the average initial BW of each pen was equal. Feed additives (LEV or AMF) were mixed with dry, ground corn and then top dressed onto the remainder of the ration in the feed bunk. A premix of 99.89% dry, ground corn and 0.11% LEV was top dressed daily to allow LEV to be supplemented at 0.5 g·animal^{-1}·d^{-1}. A premix of 99.339% dry, ground corn and 0.661% AMF was top dressed daily onto pens receiving a diet supplemented with AMF to allow AMF to be supplemented at 3.0 g·animal^{-1}·d^{-1}. Pens of cattle fed the control diet, receiving no feed additive, were fed dry, ground corn mixed with all other feed ingredients in the diet, at the rate of 454 g·animal^{-1}·d^{-1}. All steers were fed once daily at 0800 h.

Cattle were fed at the beef feedlot facility located at the Ohio Agricultural Research and Development Center in Wooster. Pens (5.4 × 5.4 m) were constructed of metal gates and cables and were located in an open-sided barn. Pens had concrete-slated floors over a 1.2-m-deep manure storage unit. An automated feeding system with feed delivered directly from a horizontal mixer system to the pens via a feed belt, with a di-

Table 2. Diet and nutrient composition in Exp. 2

	Diet[1]	
Item	HMC	DWSC
Ingredient, % (DM basis)		
Corn, high-moisture	76.00	—
Corn, whole shelled	—	76.00
Corn silage	10.00	10.00
Soybean meal	7.42	7.42
Soybean oil	3.00	3.00
Limestone	1.40	1.40
Urea	1.05	1.05
Trace mineral salt[2]	0.48	0.48
Potassium chloride	0.39	0.39
Animal and vegetable fat	0.11	0.11
Selenium, 201 mg/kg	0.05	0.05
Vitamin A, 30,000 IU/kg	0.01	0.01
Vitamin D, 3,000 IU/kg	0.01	0.01
Vitamin E, 44,000 IU/kg	0.01	0.01
Analyzed nutrient composition		
CP, %	13.05	13.30
NDF, %	12.40	12.40
Calculated nutrient composition[3]		
K, %	0.71	0.71
Ca, %	0.55	0.55
P, %	0.31	0.31
NE_m, Mcal/kg	2.23	2.23
NE_g Mcal/kg	1.55	1.55

[1]Diet was mixed with dry, ground corn or top dressed with dry, ground corn plus Amaferm (3 g·animal^{-1}·d^{-1}; Biozyme Inc., St. Joseph, MO) or Levucell SB (0.5 g·animal^{-1}·d^{-1}; Lallemand Nutrition, Blagnac, France); HMC = high-moisture corn; DWSC = dry whole-shelled corn.

[2]Contained 98% NaCl, 0.35% Zn, 0.28% Mn, 0.175% Fe, 0.035% Cu, 0.007% I, and 0.007% Co.

[3]Calculated using NRC (1996) values multiplied by the percentage of each ingredient in the feed.

verter plow used to deliver feed to each pen, was used to mix and deliver feed to pens. Automatic waterers were shared between groups of 2 adjacent pens. Cattle had 0.77 m of bunk space per animal.

Initial and final BW were calculated as the average BW obtained on 2 consecutive days at the beginning and end of the experiment. All cattle BW were taken before feeding. Cattle were weighed at 14-d intervals throughout the finishing period to monitor growth performance. Average daily gain, DMI, G:F (kg of BW gain/kg of feed), and days required to reach slaughter BW were determined for all pens. Each pen of cattle was marketed when the pen average was deemed by visual appraisal to have a minimum of 1.27 cm of backfat and a minimum average BW of 550 kg.

Cattle were transported by truck and slaughtered at 1 of 2 locations: a commercial slaughter facility or The Ohio State University Meat Science Abattoir. Because of limitations on slaughter capacity and constraints associated with sample collection, cattle were slaughtered over a 6-wk period of time. Cattle were slaughtered on a pen basis. Four pens per week were slaughtered during 6 consecutive weeks, in a manner that ensured days on feed were equal for the treatment groups. Carcass data, including those factors used to determine USDA quality and yield grades, were collected at both slaughter facilities by a USDA grader.

Statistical Analysis

Data were analyzed as a 3 × 2 factorial, with the main effects being dietary energy source (DWSC or HMC) and feed supplement (AMF, LEV, or CON). Data were analyzed using the Mixed procedures of SAS with pen as the experimental unit. Performance and carcass data were analyzed using a model that included energy source, feed supplement, and the energy source × feed supplement interaction. Means were separated using Fisher's Protected LSD test. Differences were considered significant at $P < 0.10$.

RESULTS AND DISCUSSION

Exp. 1

Animal Performance. Natural markets that do not allow the use of feed grade antibiotics or ionophores have created a need for nonantibiotic products capable of reducing acidosis and improving feed efficiency. In most cases, natural markets do not allow animals that have received hormonal implants, animal-derived feed products, or therapeutic antibiotic use.

The effects of AMF inclusion on lamb performance are shown in Table 3. Initial and final BW of lambs was similar ($P \geq 0.58$) for all treatments. Supplementation with AMF led to a numeric 8.8% increase ($P = 0.12$) in ADG, and AMF did not affect ($P = 0.82$) DMI. Amaferm resulted in a 4.9% greater ($P = 0.07$) G:F. Amaferm had no effect ($P = 0.22$) on the number of days needed to reach market BW in lambs. In a series of studies using a different *A. oryzae* extract, Tricarico et al. (2007) noted a greater ADG with cattle receiving feedlot finishing diets, although the response was related to an increase in DMI, and no greater performance occurred when DMI was restricted. For comparison, in a review by Goodrich et al. (1984), it was reported that supplementation of monensin to cattle diets resulted in a 1.6% increase in ADG and a 6.4% reduction in feed intake, resulting in a 7.5% improvement in G:F, although a considerable variability in response was noted. Lasalocid, an ionophore commonly fed to sheep, was shown to improve feed utilization by 6% (Couvaras et al., 1980). The present study indicates that a response similar to ionophores may be achievable with a high-grain diet for lambs, using AMF.

Table 3. Effect of Amaferm supplementation on lamb performance in Exp. 1

	Supplement[1]			
Item	Control	AMF[2]	SEM	*P*-value
Pens	6	6		
Initial BW, kg	29.5	29.4	0.13	0.58
Final BW, kg	54.8	54.8	0.52	0.96
DMI, kg/d	1.41	1.41	0.02	0.82
ADG, kg	0.34	0.37	0.01	0.12
G:F, kg/kg	0.245	0.257	0.004	0.07
Days on feed	73	70	1.84	0.22

[1]Control = no supplemental additive; AMF = Amaferm.

[2]Amaferm (Biozyme Inc., St. Joseph, MO) was supplemented to provide 0 or 1 g·animal^{-1}·d^{-1}, and diets were fed in pelleted form.

The need to identify nonantibiotic products for beef production systems aimed at the all-natural market is supported by research finding an increase in both *erm* and *tet* genes in fecal microbial communities of beef cattle fed small amounts of tylosin (Chen et al., 2008). This is important because of the findings that once antibiotic resistance is developed, it can persist without selective pressure for specific antimicrobials (Gillespie, 2001; Andersson, 2003). Probiotics and prebiotics may be capable of reducing pathogenic microorganisms in live animals (Gibson and Roberfroid, 1995; Elam et al., 2003). A probiotic is defined as a live microbial feed supplement that benefits the host by improving intestinal microbial balance (Fuller, 1989). A prebiotic, on the other hand, is a nondigestible nutritional compound that selectively stimulates the growth of the endogenous microflora within the digestive tract (Walker and Duffy, 1998). Both of these types of compounds have been shown by many researchers to selectively increase populations of beneficial microorganisms within the rumen (Newbold et al., 1995; Harper et al., 1996; Yoon and Stern, 1996; Beharka and Nagaraja, 1998; Krehbiel et al., 2003).

Feeding increased amounts of processed grain to cattle decreases the pH of the rumen. This results from the rapid fermentation of carbohydrates by anaerobic microbes in the rumen that leads to the production of

Table 4. Effects of Amaferm (AMF) supplementation on carcass characteristics of feedlot lambs

	Supplement[1]			
Item	Control	AMF[2]	SEM	*P*-value
Pens	6	6	—	—
HCW, kg	28.64	28.67	0.43	0.96
LM area, cm^2	14.94	15.35	0.24	0.26
12th-rib fat thickness, cm	0.74	0.85	0.05	0.14
Body wall thickness, cm	2.42	2.34	0.05	0.26
Leg score[3]	12.2	12.3	0.2	0.64
Confirmation score[3]	11.8	12.1	0.2	0.31
Lean quality score[4]	12.7	12.7	0.2	1.00
Marbling score[5]	582	549	19	0.27
Quality grade[3]	12.4	12.5	0.2	0.72

[1]Control = no supplemental additive; AMF = Amaferm (Biozyme Inc., St. Joseph, MO).

[2]Amaferm was supplemented to provide 0 or 1 $g \cdot animal^{-1} \cdot d^{-1}$, and diets were fed in pelleted form.

[3]Leg score, confirmation score, and quality grade based on a numeric scale of 10 = low choice; 11 = average choice; 12 = high choice; 13 = prime.

[4]Lean quality score objectively measured on texture, firmness, and marbling of cut surface and based on a numeric scale of 10 = low choice; 11 = average choice; 12 = high choice; 13 = low prime.

[5]Marbling based on a numeric scale of 400 to 499 = Small; 500 to 599 = Modest.

VFA. Ingestion of increased amounts of concentrates also provides the substrate for rapid proliferation of bacteria such as *Streptococcus bovis* and *Lactobacillus* species that produce large amounts of lactate from carbohydrates, which can lead to a decrease in rumen pH (Hungate et al., 1952; Slyter, 1976). Low ruminal pH is typically associated with acidosis, which can result in reduced feed intake and performance by the animal (Owens et al., 1998). The use of fungal-derived supplements may offer a natural alternative to feed grade antibiotics. These products have been shown to manipulate the rumen environment in many ways that may benefit the ruminant animal and lead to enhancements in production (Beharka and Nagaraja, 1993; Yoon and Stern, 1996; Schmidt et al., 2004). Amaferm has been reported to stimulate the growth rate of bacterial species that are capable of utilizing lactate and thus preventing the decline in rumen pH (Beharka and Nagaraja, 1998). Nisbet and Martin (1990) demonstrated that AMF stimulated the growth rate of the bacterium *S. ruminantium* and increased the utilization of lactate by this bacterium. Moreover, Waldrip and Martin (1993) reported an increase in the growth rate of the predominant lactate-utilizing bacterium *M. elsdenii* in the presence of AMF and an increase in the uptake of lactate. The increase in lactate utilization by these rumen bacterial species hinders the postfeeding decline in ruminal pH when increased amounts of concentrates are consumed by the animal (Nisbet and Martin, 1990). In the present study, although neither ruminal pH nor the presence of lactate-utilizing bacteria was measured, AMF may have stabilized ruminal pH, thereby preventing any digestive disturbances that could have occurred with the feeding of high-concentrate diet. Another *A. oryzae* product has been found to increase ruminal pH in animals being challenged with subacute ruminal acidosis (Chiquette, 2009). Thus, stabilization of ruminal pH may have contributed to the improvement in G:F that was observed in lambs fed the concentrate diet supplemented with AMF compared with lambs fed the concentrate without AMF supplementation.

Carcass Characteristics. Final BW was used as a covariate in the analysis of all carcass measurements and did not differ ($P = 0.96$) among treatments (Table 3). Supplementation of AMF had no effect ($P \geq 0.14$) on any carcass characteristics measured in the study (Table 4). Amaferm has been shown to not result in an increase in propionate with grain-based diets (Gomez-Alarcon et al., 1990). No differences in intramuscular fat were expected; Smith and Crouse (1984) reported that adipocytes associated with intramuscular adipose tissue were primarily derived from glucose, originating as propionate.

Exp. 2

Growth Performance. Main effects are presented for cattle growth performance because the only interaction observed occurred with G:F between energy source and supplement type ($P = 0.03$; Figure 1). Cattle supplemented with AMF had a 7.2% improvement ($P < 0.05$) in G:F (0.208 vs. 0.194) when DWSC was fed but not when HMC was fed. This improvement in G:F was primarily driven by a numerical decrease in DMI in steers fed DWSC with AMF compared with steers fed DWSC with no supplement, although this difference was not significant ($P = 0.30$). In contrast, there was no difference in DMI between AMF- and CON-fed cattle in the HMC diet.

Initial and final BW of steers were similar ($P \geq 0.30$) among all treatments (Table 5). During the finishing period, ADG of steers did not differ ($P = 0.99$) between the different supplement types, although HMC increased ($P = 0.09$) ADG in cattle compared with

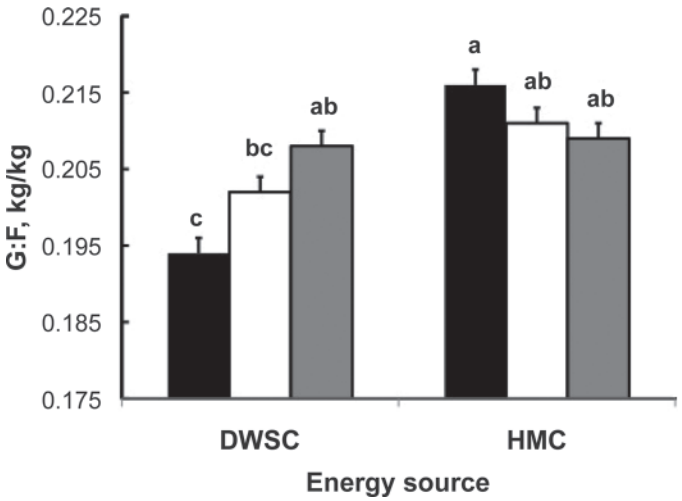

Figure 1. Feed efficiency (G:F) values for energy source (DWSC = dry, whole-shelled corn and HMC = high-moisture corn) and supplement type [black = control (no supplemental additive); white = Levucell SB (0.5 g·animal^{-1}·d^{-1}; Lallemand Nutrition, Blagnac, France); and gray = Amaferm (3 g·animal^{-1}·d^{-1}; Biozyme Inc., St. Joseph, MO)] during the finishing period in Exp. 2. Interaction of energy source and supplement type on feed efficiency was $P = 0.03$; therefore, values without a common letter differ ($P < 0.05$).

DWSC. Dry matter intake was similar ($P = 0.30$) among supplement types. However, a difference ($P = 0.03$) in DMI was observed between the 2 energy sources, whereas steers receiving the HMC diet consumed 2.4% less feed than those steers fed DWSC. In agreement with the current study, Ladely et al. (1995) reported that cattle fed HMC consumed less DM, gained BW faster, and were more efficient than cattle fed dry-rolled corn. High-moisture corn is more extensively digested in the rumen and a greater total-tract starch digestibility than dry-rolled corn in finishing corn diets (Owens et al., 1986).

No previous studies have reported the effects of AMF on growth performance in feedlot cattle, but AMF has been shown to increase populations of bacteria in vitro and within the rumen (Beharka et al., 1991; Beharka and Nagaraja, 1993; Varel and Kreikemeier, 1994). Amaferm is thought to have 2 modes of action; it increases populations of ruminal bacteria and increases the growth rate and activity of rumen fungi (Harper et al., 1996; Welch et al., 1996; Beharka and Nagaraja, 1998; Chang et al., 1999). The effects of AMF have been demonstrated to be influenced by diet and forage type, which may explain the different effects AMF had on the 2 corn types (Beharka and Nagaraja, 1993). However, most previous studies have looked at the effects of AMF with forage-based diets as opposed to concentrate-based diets.

The lack of a performance response with LEV was also reported by Pinos-Rodríguez et al. (2008) with Holstein calves fed a grain-based diet, and in that trial, there was no alteration in ruminal propionate due to LEV supplementation. However, there was an increase in ruminal ammonia N and propionate with the addition of *S. cerevisiae* CNCM I-1077, and an increase in DMI (Pinos-Rodríguez et al., 2008). These findings may be explained by the results of Oeztuerk et al. (2005) who reported that *S. boulardii* was digested by ruminal microbes, and the effect was that it is utilized as a substrate in ruminants, becoming a prebiotic rather than a probiotic.

Carcass Characteristics. The results for traits related to carcass characteristics are shown in Table 6. There were no interactions ($P \geq 0.13$) between energy source and supplement type observed; therefore, the main effects are presented. Neither energy source nor supplement type affected ($P \geq 0.13$) carcass traits measured in the study. In support of these findings, Huck et al. (1998) reported no differences in carcass characteristics between different corn processing methods when fed in combination with steam-flaked grain sorghum. There have been no previous studies that have looked at the impact of AMF on carcass characteristics in feedlot cattle. However, the lack of any effect on carcass characteristics due to AMF or LEV may have been expected because a review by Krehbiel et al. (2003) reported that dressing percent, quality grade, or percentage USDA choice of carcasses from feedlot steers were not influenced by direct-fed microbials containing varying concentrations and strains of *Lactobacillus acidophilus* and *Propionibacterium freudenreichii.*

Table 5. Main effects of energy source and supplement type on steer performance in Exp. 2

	Energy source[1]				Supplement type[2]				
Item	DWSC	HMC	SEM	*P*-value	Control	LEV	AMF	SEM	*P*-value
Pens	12	12	—	—	8	8	8	—	—
Initial BW, kg	300	300	0.68	0.75	300	299	300	0.8	0.58
Final BW, kg	551	558	4.6	0.31	554	554	557	5.6	0.93
Days on feed	150	150	3.9	1.00	149	150	150	4.8	0.97
ADG, kg/d	1.69	1.73	0.04	0.09	1.71	1.71	1.71	0.05	0.99
DMI, kg/d	8.4	8.2	0.06	0.03	8.4	8.3	8.2	0.2	0.30
G:F,[3] kg/kg	0.202	0.212	0.002	0.002	0.205	0.206	0.209	0.002	0.61

[1]DWSC = dry whole-shelled corn; HMC = high-moisture corn.

[2]Control = no supplemental additive; LEV = Levucell SB (0.5 g·animal^{-1}·d^{-1}; Lallemand Nutrition, Blagnac, France); AMF = Amaferm (3 g·animal^{-1}·d^{-1}; Biozyme Inc., St. Joseph, MO).

[3]Energy source × supplement type interaction ($P = 0.03$) and presented in Figure 1.

Table 6. Main effects of energy source and supplement type on carcass characteristics of steers in Exp. 2

	Energy source[1]				Supplement type[2]				
Item	DWSC	HMC	SEM	*P*-value	Control	LEV	AMF	SEM	*P*-value
Pens	12	12	—	—	8	8	8	—	—
HCW, kg	340	345	3.4	0.33	342	343	343	4.1	0.99
Dressing percent	61.7	61.8	0.17	0.66	61.8	61.9	61.6	0.21	0.62
12th-rib fat thickness, cm	1.32	1.40	0.05	0.24	1.30	1.36	1.42	0.06	0.33
LM area, cm^2	79.4	81.7	1.0	0.13	79.9	80.7	81.1	1.3	0.79
KPH, %	2.3	2.4	0.16	0.49	2.3	2.5	2.3	0.2	0.63
USDA marbling score[3]	534	548	9.2	0.30	551	539	532	11.3	0.50
USDA quality grade[4]	4.95	5.12	0.10	0.24	5.14	5.00	4.96	0.12	0.56
USDA yield grade[5]	3.17	3.20	0.09	0.79	3.13	3.21	3.21	0.11	0.81

[1]DWSC = dry, whole-shelled corn; HMC = high-moisture corn.

[2]Control = no supplemental additive; LEV = Levucell SB (0.5 $g \cdot animal^{-1} \cdot d^{-1}$; Lallemand Nutrition, Blagnac, France); AMF = Amaferm (3 $g \cdot animal^{-1} \cdot d^{-1}$; Biozyme Inc., St. Joseph, MO).

[3]Marbling based on numeric scale of 400 to 499 = traces; 500 to 599 = small; 600 to 699 = modest.

[4]Quality grade based on a numeric scale of 4 = low choice; 5 = average choice; 6 = high choice; 7 = prime.

[5]Yield grade as calculated by the regression equation (USDA, 1997).

In conclusion, AMF supplementation at 1 $g \cdot animal^{-1} \cdot d^{-1}$ throughout the finishing period could be used to improve G:F in lambs fed a concentrate diet as it was found to improve G:F by 4.9%, with no change in feed intake. Steers fed HMC had an improved feed efficiency compared with steers fed DWSC, regardless of feed supplement. Addition of AMF to a beef feedlot diet composed of DWSC resulted in a 7.2% improvement in G:F, with no improvement in G:F with HMC-based diets. Results indicate that at the amounts fed, AMF may improve efficiency of BW gain for lambs and steers fed dry corn-based finishing diets; however, the same may not be seen with LEV.

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