Forages in the feedlot

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Introduction

Conventional wisdom has always been that forage inclusion in a finishing diet should not be greater than the level required to promote adequate “scratch factor” or effective fiber to ensure rumen health and microbial protein synthesis. Purchased forage is considerably more expensive per unit of energy relative to cereal grains; hence, forage is often not included in finishing diets using formulation systems based upon least-cost diet formulation. However, forage is nearly always forced into all finishing diets at some minimum mandatory inclusion level as a “functional” ingredient based upon the feeding and cattle management capabilities of the feedlot (Zinn and Ware, 2003). Unfortunately, the terms “roughage” and “forage” serve as synonyms in many beef circles. When forage is included as a “functional” ingredient it is more appropriately termed “roughage”. When this “roughage” is fed at a level greater than that required for “scratch” it is more appropriately termed “forage”. Hence, we should consider our choice of words and application in practice as two distinctly different management strategies. On average, reducing roughage inclusion will enhance dry matter feed conversion by 0.3 to 1.0% unit for each point of roughage that is removed from a finishing diet. In the Southern Plains (SP) region of the United States feedlot capacity is greater and as a result of the sheer size of the feedlot operation, the majority of feedstuffs are procured from off-farm entities. This is one reason that feed costs per unit of dry matter (DM) in SP feedlots are considerably greater than for feedlots in the Northern Plains (NP) region. Under SP finishing systems, feed conversion is the primary measure of production efficiencies. Dry matter feed conversion (pounds of feed divided by pounds of gain) is closely related to economic returns when feeding purchased feedstuffs. Most NP cattle feeders are integrated crops- and livestock-systems that produce a large portion of their annual feedstuff inventory on the farm. Previous research from this research center has indicated that efficiency (measured as pounds of beef produced per acre of crop-land) is greater or not decreased when feeding greater levels of roughage (as corn silage) to finishing beef steers (Rusche et al., 2020; Buckhaus and Smith, 2021). The aim of this essay is to challenge conventional wisdom related to roughage inclusion levels in finishing diets and illustrate the concept of “forages in feedlot diets” based upon maximizing beef production from a fixed land based.

Why is roughage needed in a finishing diet?

Roughage is an essential component of feedlot finishing diets. Proper harvesting, processing, storage, feed-out management, and inclusion level are all critical points to consider between feedlot managers and technical support personnel. Conversations related to procurement, processing, storing, and feed-out management of cereal grains are a common occurrence between feedlot managers and their nutritionist or feed sales person. The conversation related to roughage in finishing cattle diets typically only starts after a string of digestive deaths, if feed bunks are getting tough to manage, the operation is displeased with handling and/or mixing characteristics of the roughage source in the diet, or the roughage supply has been depleted.

Some level of roughage is fed to all feedlot cattle in the North America, even in regions where roughage is not an easily sourced feed ingredient. In the NP region, it is common to see cattle fed from a stuffer (self-feeder) using a whole-shelled corn based diet with an intake control pellet. Still, few producers routinely feed a zero-roughage finishing diet. If a zero-roughage diet is fed to finishing cattle, management is key, and factors related to corn processing, intake/bunk management, and cattle management become increasingly important. Hence, the reason that feedlots feeding cattle using a stuffer elect to feed whole-shelled corn (altered corn processing) and an intake control pellet (altered intake management). Roughages serving as a functional ingredient are included in high-concentrate diets fed to finishing cattle for a variety of reasons. One such reason is that including roughage in a high-concentrate diet changes the physical form of the diet. This changing in the physical form of the diet makes each bite cattle take more similar and dilutes “hot-spots” (i.e. pockets of readily fermentable carbohydrates) in the diet; thus, there is less risk for ruminal acidosis when roughage is fed. Increasing roughage has also been shown to increase time spent ruminating each day, thereby resulting in a more favorable (greater) ruminal pH environment (Gentry et al., 2016). Altered time spent ruminating each day also influences ruminal fermentation and digesta kinetics. In some instances, roughage can be used to contribute protein, minerals, and/or vitamins to a ration.

Another consideration for added roughage is effects on diet mixing and bunk management. If requirements for nutrients (macro- or micronutrient) are met, daily gain is a very predictable function of daily intake (Zinn et al., 2008) if diet energy density is known. Improper diet mixing that yields a diet with poor physical characteristics in the bunk can create issues with cattle sorting and alter subsequent nutrient intake that can among other things result in 1) detrimental effects to digestive function and 2) altered energy intake that then can influence cattle tracking and timely selling of finished cattle. Diets that are too dense (too fine of particles) can cause issues with compaction in the feed manger and can create issues with diet consumption. Additional roughage can help reduce separation of fine particles from the diet in the feed batching system and also in the feed bunk (Buckhaus et al., 2020). Use of a moist, bulky roughage with intermediate particle size and a moderate density can allow for better incorporation with other diet constituents and results in a diet with a texture that cattle can easily grasp and eat. Plus, ensuring that cattle consuming the appropriate proportion of nutrients that match the intended formulation can become an issue with finer particle diets even if cattle are not able to readily sort!

Does roughage source matter?

Alfalfa hay and corn silage are what some might call “legacy” or “reputation” roughage sources. Their popularity as roughage sources in North American feedlot diets are un-equivocal. Samuelson et al. (2016) indicated that alfalfa hay (58.3% of respondents) was the most common roughage source used in commercial feedlots and indicated that the most common secondary roughage source used was corn silage (39.1% of respondents). Feeding value of a roughage source is a function of the roughage sources nutrient content, chemical/physical characteristics of its fiber, palatability and acceptability, and any associative effects with other diet ingredients (Zinn and Ware, 2003). Changes in rate of degradation and rate of passage when an un-familiar roughage source is fed in replacement of a “legacy” roughage can alter daily intake and cattle growth performance; hence, when a nutritionist faces this problem in the field, the primary concern with roughage source changes is impacts on energy intake and digestive function (Zinn and Ware, 2003). There are models available to help assess this roughage change in feedlot diets (Zinn and Ware, 2003) so that this change is not blindly done. However, as a rule of thumb, roughage source substitution will likely not matter as long as the roughage is: 1) processed adequately to promote uniform mixing with other diet ingredients (Buckhaus et al., 2020) and 2) an equivalent amount of neutral detergent fiber (NDF) from roughage is fed (Benton et al., 2015). It is important to realize that roughages in feedlot diets do in fact do more than simply supply effective NDF to the diet! Hence, it is important to recognize that roughage source and/or level can alter mixing, bunk separation, chewing, rumination, ruminal acidosis, and health. If roughage NDF level in the diet fed to cattle is similar when feeding two different roughage sources, then there is no reason to expect growth performance to differ appreciably among sources if chop length is similar and storage characteristics are not an issue. Hence, differences in realized production efficiency will be recognized through improvements in outputs from the fixed land base that produced the feed (i.e. yield potential and fixed/variable costs associated with production of the roughage crop).

Does roughage inclusion level matter?

Samuelson et al. (2016) indicated that 8 to 10% roughage inclusion (DM basis) was the most common roughage feeding level in diets fed to finishing steers and no respondents indicated feeding finishing diets with greater than 12% roughage inclusion (DM basis). Roughage level (DM basis) is a poor indicator of “effective” roughage level since NDF level is so variable within and among roughages fed to feedlot cattle.

Ideally, roughage NDF level should be around 5 to 7% (DM basis) to provide adequate effective fiber and promote ruminal health and microbial protein synthesis. Using a tabular NDF value for alfalfa hay (NASEM, 2016) of 41.73% (NDF DM basis), the roughage NDF level fed from the primary roughage source to the majority of feedlot cattle is ~3.75% roughage NDF level (DM basis). There is potential to increase chop length if roughage NDF level is too low in an effort to increase the physically effective fiber level of the diet. However, this might come at the expense of poorer mixing and handling characteristics, increased bunk sorting, and increased potential for bouts of sub-clinical acidosis caused by improper mixing and poor incorporation into the total mixed ration as mentioned above.

Beef production from a fixed land base

Corn silage is a cornerstone feed ingredient in the NP. Corn silage production in the United States has been a widely adapted for over a century. Based upon recent USDA data (2020) corn silage was grown on 360,000 acres in SD with an average yield (as-is basis) of 18 tons per acre resulting in 6.48 million tons of corn silage produced in SD in 2020. Like many others in SD, we harvest and store corn silage at our Research Center's in Brookings and Beresford because it serves as an excellent diet conditioner and can be used in a variety of confinement feeding situations (i.e. growing or finishing). Other advantages of using corn silage as a roughage source in finishing cattle diets is that is can be harvested in a single event annually compared to multiple harvests required to generate sufficient inventory for feeding as is the case with other forage sources. The year 2021 presents unique opportunities specifically related to corn production and the resiliency of an integrated crops-livestock system. According to the USDA-NASS data from the week ending on August 8, 2021, approximately 10% of the South Dakota corn crop was rated as very poor. With an estimated 5.1 million acres of corn grain planted in South Dakota in 2021, and 10% of the crop rated as poor (i.e. this crop is getting chopped..), we can expect an increase in corn silage production of approximately 41% in 2021 over 2020. Farmers with ruminants will be able to turn this crop into cash via livestock and in essence walk the failed crop off the farm or purchase the failed corn crop as corn silage from a neighbor.

When feeding greater levels of roughage to finishing cattle feed conversion is worsened, but often times the apparent energetic utilization of the diet is increased. We have demonstrated this principle at the South Dakota Station previously (Rusche et al., 2020; Buckhaus and Smith, 2021). In both studies mentioned above, feed conversion was worsened or un-changed as greater levels of roughage (as corn silage) were fed, but the ratios of observed-to-expected measures related to applied energetics were improved or not changed as greater levels of roughage were fed. We believe the basis for this is likely improved ruminal health when a greater level of roughage is fed to finishing cattle that results in an improvement in the apparent energy retention per unit DM intake. Furthermore, beef production from a fixed land based was either: 1) greater (Rusche et al., 2020) or 2) un-changed (Buckhaus and Smith, 2021) when feeding elevated levels of roughage (in this case corn silage) to finishing steers. Johnson et al. (2017) indicated that net return to corn acres dedicated to cattle feeding during the last 18 years was 6.2 times greater than that realized through marketing corn through a local elevator. Our data suggests that 9 weight steers to finish at 1500 lbs (600 lbs of live weight gain) fed 12 to 30% corn silage inclusion in finishing diets with 20% corn ethanol co-product, 5% of a suspended supplement, and the balance of the diet as either dry-rolled corn or a 50:50 blend (DM basis) of high-moisture and dry-rolled corn require approximately 0.30 acres of cropland to reach market weight. This is approximately 2,000 lbs of live weight/acre (600 lbs gain/head divided by 0.30 acres). Just making some quick assumptions that value of gain is $1.00/lb; that comes out to a return of $2,000/acre. If cost of gain is $0.50/lb, then net returns are $0.50/lb, this comes out to a total return of $1,000/acre. With 200 bu/acre corn, one needs to secure $5.00/bu to return the same money as cattle feeding provided this integrated crops-livestock producer. Of course, the caveat here is there are no wintertime vacations to Disney World in Orlando with the family, because there are cattle chores to tend.

Feed-out management

When feeding cattle at our Research Center's we like to avoid un-necessary changes! Specifically, we aim to minimize any major ingredient changes to the diet as much as possible during the last month prior to harvest. Often times we have spent so much time and effort getting the cattle to this point that we are not trying to create issues by trading out corn stalks for alfalfa hay because we did not manage inventory properly. As such, our Research Center has had an interest in easy feeding strategies that: 1) optimize animal health and growth performance and 2) improve efficiencies of the entire farm operation by using more homegrown crops and minimizing waste of on farm procured feedstuffs. To evaluate some aspects of these goals, we recently conducted a 210-d growing-finishing experiment using pre-conditioned single source Charolais × Red Angus steers (n = 46 steers). All steers were vaccinated for viral respiratory pathogens and clostridia species, as well as treated for internal and external parasites 50-d prior to the initiation of the present study. Treatments included: 1) A single diet program (targeted a 59 Mcal/cwt NEg diet fed for 210-d; 1D) or 2) two diet program (targeted a 55 Mcal/cwt NEg diet fed for 98-d, a 59 Mcal/cwt NEg diet fed for 14-d, and a 63 Mcal/cwt NEg diet fed for 98-d; 2D). All steers were implanted initially (d 1) with a 100 mg trenbolone acetate (TBA) and 14 mg estradiol benzoate (EB) implant (Synovex Choice, Zoetis, Parsippany, NJ) and re-implanted with a 200 mg TBA and 28 mg EB implant (Synovex Plus, Zoetis) on d 112. Ractopamine HCl was fed at a rate of 300 mg/steer·d^{-1} for the final 28-d prior to harvest.

Table 1. Growing, finishing, and cumulative growth performance response.[a]

	Treatment			
Item	1D	2D	SEM	*P* – value
Steers, n	23	23	-	-
Pens, n	5	5	-	-
Live weight, lb				
Initial	615	615	3.1	0.93
112-d	1016	981	13.7	0.06
210-d	1363	1367	21.2	0.87
Average daily gain (ADG), lbs				
1-112 d	3.58	3.27	0.117	0.06
113-210 d	3.54	3.94	0.093	0.01
1-210 d	3.56	3.58	0.101	0.86
Dry matter intake (DMI), lbs				
1-112 d	20.62	20.58	0.334	0.91
113-210 d	23.79	23.77	0.606	0.97
1-210 d	22.10	22.07	0.342	0.93
ADG/DMI				
1-112 d	0.174	0.159	0.0054	0.05
113-210 d	0.149	0.166	0.0020	0.01
1-210 d	0.161	0.162	0.0027	0.76
DMI/ADG				
1-112 d	5.75	6.29	-	-
113-210 d	6.71	6.02	-	-
1-210 d	6.21	6.17	-	-
Observed-to-expected DMI				
1-112 d	1.12	1.15	0.023	0.15
113-210 d	1.00	1.00	0.029	0.90
1-210 d	1.05	1.05	0.017	0.91

[a] All BW were reduced 4% to account for digestive tract fill.

Growing (initial to d 112), finishing (d 113 to 210), and cumulative (initial to d 210) growth performance responses are presented in Table 1. Initial BW and final BW were similar (*P* ≥ 0.87) between treatments, however, BW in steers from 1D at the end of the growing period (d 112) tended to be 3.6% (*P* = 0.06) greater than steers from 2D. Average daily gain tended (*P* = 0.06) to be 9.5% greater for 1D compared to 2D during the growing period and ADG was increased (*P* = 0.01) for 2D compared to 1D by 11.3% during the finishing phase of the experiment. Hence, cumulative ADG did not differ between treatments (3.56 vs. 3.58 ± 0.101 lbs) for 1D and 2D, respectively. Growing (*P* =0.91), finishing (*P* = 0.97), and cumulative (*P* = 0.93) DMI did not differ between treatments. During the growing phase of production, steers from 1D had improved (*P* = 0.05) feed conversion by 9.4% compared to 2D. During the finishing phase, steers from 2D had enhanced feed conversion by 11.4% (*P* = 0.01). Thus, cumulative gain to feed ratio was not appreciably different (0.161 vs 0.162 ± 0.0027) for 1D and 2D, respectively. Finally, the ratio of observed-to-expected DMI (lower number is better; this describes the apparent energy retention per unit DMI) did not differ between diets for any periods measured (*P* ≥ 0.15).

Table 2. Carcass trait responses.

	Treatment			
Item	1D	2D	SEM	*P* – value
Steers, n	22	23	-	-
Pens, n	5	5	-	-
Carcass traits				
HCW, lbs	881	884	12.9	0.82
DP, %	64.55	64.70	0.487	0.77
REA, in^2	14.44	14.92	0.448	0.34
RF, in	0.48	0.47	0.030	0.85
Marbling[a]	526	529	33.7	0.95
KPH, %	1.87	1.90	0.064	0.39
Yield grade[b]	2.79	2.64	0.092	0.18
Retail Yield, %[c]	50.92	51.19	0.225	0.29
EBF, %[d]	30.06	29.82	0.517	0.67
AFBW, lbs[d]	1309	1322	31.4	0.70
Liver scores, %[e]				
Normal	77.0	92.0	5.72	0.14
A-	9.0	0.0	3.94	0.18
A	5.0	0.0	3.54	0.37
A+	9.0	8.0	5.24	0.90

[a] 400 = small^{00}
[b] According to the regression equation described by USDA (1997).
[c] As a percentage of HCW according to Murphey et al. (1960).
[d] Calculated according the equations described by Guiroy et al. (2002)
[e] According to the Elanco Liver Scoring System: Normal (no abscesses), A- (1 or 2 small abscesses or abscess scars), A (2 to 4 well organized abscesses less than 1 in. diameter), or A+ (1 or more large active abscesses greater than 1 in. diameter with inflammation of surrounding tissue).

Carcass trait responses are located in Table 2. There were no differences (*P* ≥ 0.18) detected between treatments for HCW, DP, REA, RF, USDA marbling score, KPH, yield grade, retail yield, EBF, or body weight at 28% estimated EBF (AFBW). The proportion of livers classified as normal tended (*P* = 0.14) to be decreased by 16.3% in steers from 1D compared to 2D. There is some evidence that liver abscesses in cattle develop early in the feeding period (Nagaraja and Chengappa, 1998; Müller et al., 2018), as such, consuming a greater roughage level early on in the feeding period might have had some influence on the development of liver abscesses between treatments.

Table 3. Feed-out face management.

	Treatment			
Item	1D winter (16% roughage)	2D winter (25% roughage)	1D summer (16% roughage)	2D summer (7% roughage)
As-is silage intake, lbs/hd/d	8.9	10.3	13.9	4.5
No. head required				
6 inches	808	699	514	1600
12 inches	1616	1398	1035	3200

Still, with no apparent difference in growth performance or carcass characteristics, the single diet system can be used as a management tool to enhance feed-out face management. The idea is that feeding greater levels of silage in finishing diets allows a farmer feeder to incorporate more home-raised feedstuffs with reduced spoilage and shrink loss associated with improper feed face management. Imagine if you will a 30' wide and 12' tall concrete bunker that might be found on a 1,000 head NP feedlot operation. The ensiled feed has a bulk density of 40 lbs/ft^3 (as-is basis); hence, the feed removed daily would need to be 7,200 lbs in the winter (6" removed daily) or 14,400 lbs in the summer (12" removed daily) to minimize losses caused by air infiltration in the silage mass. Table 3 illustrates the number of head required to remove the appropriate amount of feed each day to minimize spoilage losses in each season (winter or summer) based upon intake level, inclusion level, and daily removal depth. As seen in Table 3, use of the single diet allowed for better feed-out face management during the summer due to proper removal of the required amount of feed each day in line with the capacity of the operation (1,000 hd) to minimize heating and spoilage losses. This study illustrated that, NP feedlot producers can feed a single growing-finishing diet to pre-conditioned beef steers with minimal effects on overall growth performance or carcass traits. Production period (growing vs. finishing) responses for growth performance were as anticipated for varying levels of roughage fed. Additionally, feed-out management of ensiled feeds, could be improved and wastage reduced, especially in summer months, by feeding a single growing-finishing diet to beef steers with no influence on growth performance or carcass traits. This recommendation is made with a bit of caution. These were high-growth potential beef steers from western South Dakota; their mature BW (AFBW) was more than 1300 lbs. Hence, the single diet growing-finishing system might not be suitable for cattle of smaller framed genetics and if used might result in overly-fleshy cattle that finish sooner than they would have been if they had been grown more slowly on a higher forage diet prior to being fed a greater energy density diet during the finishing phase of production.

Conclusion

The terms roughage and forage are not synonyms. Feeding a fibrous feedstuff at a level greater than that required for adequate effective fiber to promote ruminal health and microbial protein synthesis in a finishing diet is more appropriately termed "forage in a feedlot diet". Feeding elevated roughage levels to finishing cattle fed concentrate-based diets results in poorer economic performance when measured on an individual animal basis (i.e. F:G), however, beef production per acre of cropland is increased or not different, and energetic efficiency of dietary energy capture is enhanced when greater levels of roughage is fed to finishing cattle. This alteration in apparent energy capture when increased roughage is fed to finishing cattle is likely due to improved ruminal health, lessened bouts of sub-clinical acidosis, reduced inflammation, or a combination of these things, that result in a reduced maintenance energy requirement. Cattle feeders in the NP region that are integrated crops- and livestock systems should evaluate production efficiencies based upon beef yield per acre and not dry-matter feed conversion per pound of gain.

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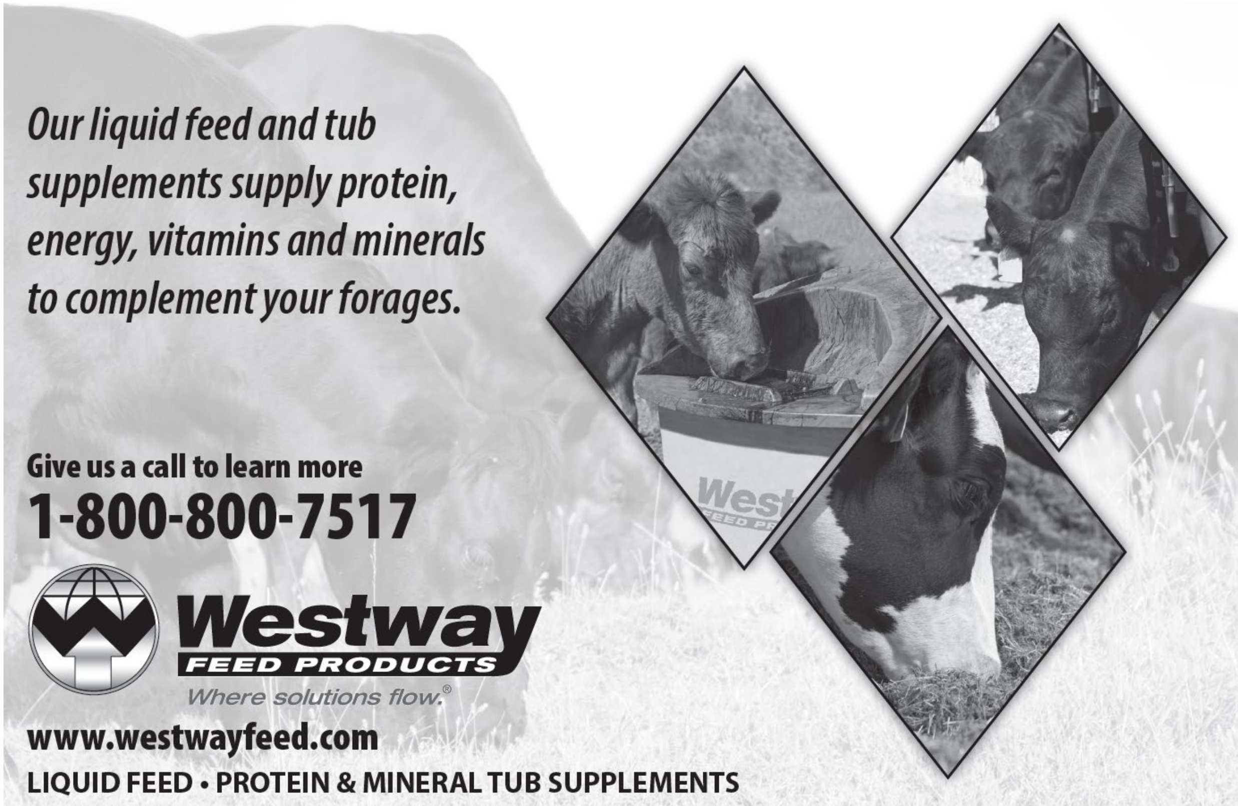
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