Evaluation of Rumen Undegradable Protein Sources Fed in an Organic Production System

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Summary with Implications

Fifty-eight Holstein steers with an initial body weight of 469 lb were fed 1 of 5 dietary treatments containing different rumen undegradable protein (RUP) sources: control with no supplemental protein, field peas, field peas plus fish meal, soybean meal, and SoyPass, a treated soybean meal high in RUP. These protein sources replaced corn in a base diet of 65% dry rolled corn, 30% alfalfa haylage, and 5% supplement in order to balance for metabolizable protein (MP). The objective of this study was to compare how rumen undegradable protein sources that can be found in organic production systems affect the growth and performance of lightweight Holstein steers. Using supplemental RUP to balance for MP improved F:G by 25% in the first feeding phase regardless of RUP source. Over the feeding period, steers in all treatments gained similarly and had similar final body weight, but steers fed field peas plus fish meal tended to be more efficient than other calves. Supplementing field peas or field peas and fish meal did not result in an increase in cost of gain over calves not fed supplemental RUP. Supplemental RUP increased live weight gained by up to 14.2%. These data indicate that using feedstuffs that can be found in organic production systems to supplement RUP can result in improved F:G without increasing cost of gain.

Introduction

In most production systems, the diets need to be adequate for protein to optimize performance. The metabolizable protein (MP) system should be used to ensure adequate types of protein are being used most efficiently. The MP system accounts for the portion of the crude protein (CP) that enters the rumen as degradable protein used by rumen microbes (RDP), and the portion of CP that escapes microbial degradation (RUP). The MP system also accounts for protein contained within the microbes that exit the rumen with ingesta and can be digested by the animal. Existing research suggests that young, growing calves benefit from supplementary RUP. This is the protein component most often deficient in high forage growing diets and must be supplemented in order to meet MP requirements. In an organic beef production system, where requirements dictate pasture must provide 30% of the diet, supplemental RUP is likely required. Using distillers grains as a protein or energy source usually meets the protein needs of a growing calf, but organic distillers grains are not widely available to organic producers. Furthermore, a steady supply of organic feeder calves is important in producing organic beef, and organic dairies may be the most reliable year-round source of organic feeder calves. The objective of this study was to compare sources of RUP and examine their effects on the performance of lightweight Holstein steer calves in a simulated organic production system.

Procedure

This study utilized 58 Holstein steers (initial body weight= 469 ± 55 lb) in a randomized complete block design. Steers were fed individually using the Calan gate system. Initial BW was established by limit-feeding calves an estimated 2% of body weight (BW) of a diet containing 50% alfalfa hay and 50% Sweet Bran (Cargill) over 5 days to equalize gut fill and collecting individual body weights over the last 3 days of limit feeding. The 5 treatments imposed were based on protein source and included control (CON) with no supplemental protein, field peas (FP), field peas and fish meal (FPFM), soybean meal (SBM), and SoyPass (SP). Treatment diets were fed over 3 phases 65 days in length, and all calves were moved to the CON diet at 194 days due to a lack of response to protein inclusion. These steers were not grazed and were treated with antibiotics and antiparasitics as needed.

All diets, except for CON, were balanced for MP using the initial BW for each feeding phase. Amounts of protein source included on a DM basis varied based on the composition of the protein provided by the source; for example, less SoyPass needed to be included compared to soybean meal because SoyPass has a higher RUP content. Phase feeding these protein sources ensured that protein requirements were being met on day 1 of each phase as calves grew and the amount of RUP needed to balance for MP decreased. All diets contained 30% alfalfa haylage in order to mimic the 30% grazed forage requirement of an organic system and the remainder of the diet contained dry rolled corn (Table 1). A supplement meal consisting of fine ground corn and limestone was included at 5% for all diets except FPFM, which had all or a portion of that supplement meal consisting of fish meal. All feed ingredients used were conventionally grown; the soybean meal was solvent extracted. SoyPass is not available as an organic feed, but was included as a positive control. Diets were mixed and offered daily. Feed refusals were collected and weighed weekly, dried for 48 hours in a 60° C forced-air oven to calculate DMI.

Interim weights were collected on the last day of one feeding phase and the first day of the next feeding phase, averaged, and shrunk 4% to account for gut fill and establish final BW for each phase. Because no significant differences were observed after the day 63 (d63) interim BW, only that interim BW will be examined here. At the end of the individual feeding period, calves were limit fed the CON diet at 1.8% of their body weight for four days and individual

Table 1. Diets fed to Holstein steers in four phases to simulate an organic production system

	Dietary Treatment[1]				
Ingredient, %DM[2]	CON	FP	FPFM	SBM	SP
Phase 1, d1 to d63					
Dry Rolled Corn	65	11	35	33	55.25
Alfalfa Haylage	30	30	30	30	30
Fish Meal	-	-	4	-	-
Field Peas	-	54	30	-	-
Soybean Meal	-	-	-	32	-
SoyPass	-	-	-	-	9.75
Supplement	5	5	1	5	5
Phase 2, d64 to d132					
Dry Rolled Corn	65	26	43	42	57.75
Alfalfa Haylage	30	30	30	30	30
Fish Meal	-	-	3	-	-
Field Peas	-	39	22	-	-
Soybean Meal	-	-	-	23	-
SoyPass	-	-	-	-	7.25
Supplement	5	5	2	5	5
Phase 3, d133 to d194					
Dry Rolled Corn	65	43	55	52	61
Alfalfa Haylage	30	30	30	30	30
Fish Meal	-	-	2	-	-
Field Peas	-	22	10	-	-
Soybean Meal	-	-	-	13	-
SoyPass	-	-	-	-	4
Supplement	5	5	3	5	5
Phase 4, d195 to d214					
Dry Rolled Corn	65	65	65	65	65
Alfalfa Haylage	30	30	30	30	30
Fish Meal	-	-	-	-	-
Field Peas	-	-	-	-	-
Soybean Meal	-	-	-	-	-
SoyPass	-	-	-	-	-
Supplement	5	5	5	5	5

[1]CON = Control, FP = Field Peas, FPFM = Field Peas + Fish Meal, SBM = Soybean Meal, SP = SoyPass

weights were collected the last three days and averaged to establish ending BW. Average daily gain (ADG) and feed efficiency (F:G) were calculated.

For the economic analysis, organic prices were sourced using AMS market data during the feeding period. Alfalfa haylage was priced at $257.77/ton DM after being shrunk 15%. Dry rolled corn was $386.43/ton DM with a 2% shrink applied. Soybean meal was priced at $1,020.30/ton DM after a 2% shrink was applied. Due to the lack of market data, organic field peas were priced at $16 per as-is bushel or $622.40/ton DM after a 5% shrink was applied, and organic fish meal was priced equivalent to conventional fish meal at $1,933.80/ton DM after a 5% shrink. SoyPass was priced at $580.94/ton after a 2% shrink. The supplement used in all diets was priced at $152.78/ton DM with a 2% shrink.

Performance and economic data were analyzed as a randomized complete block design using the Glimmix procedure of SAS (9.3, SAS Institute Inc., Cary, NC) with the Tukey adjustment applied. Individual animal was the experimental unit. Treatment and block were considered fixed effects. Treatment averages were calculated using the LSMEANS option of SAS. Frequency data were analyzed using the Glimmix procedure of SAS with means of proportions for the frequency data determined using the ILINK option. Treatment differences were significant at an α value less than or equal to 0.05.

Results

Initial BW was different ($P = 0.03$) among treatments, with SP and FPFM calves weighing the most and CON calves weighing the least; while the FP and SBM groups were intermediate (Table 2). While some differences in initial BW exist, they are quite small. In Phase 1, protein inclusion resulted in differences ($P = 0.03$) in d63 BW with the CON group weighing the least and FP, FPFM, SBM, and SP groups having similar BW. This was expected, since the CON treatment was MP-deficient while all other treatments were balanced for MP and in theory should have performed similarly. There was also a difference ($P = 0.04$) in ADG between treatments, with calves in the CON group gaining the least and the SP group gaining the most; steers fed FP, FPFM, and SBM were intermediate. The differences in d63 BW and ADG resulted in a difference ($P < 0.01$) in F:G in the first phase; the CON group had the highest F:G while steers fed FP, FPFM, SBM, and SP were similar, with supplemental RUP resulting in an approximate improvement in F:G of 25% regardless of source. No difference ($P = 0.20$) in DMI was detected in Phase 1.

Although calves in the CON group started Phase 2 at a BW disadvantage compared to the other treatments, final BW did not differ ($P = 0.25$). This indicates some form of compensation for the protein deficiency imposed upon the CON group, although final BW was not numerically equivalent among treatments. However, no differences ($P \geq 0.43$) were detected for ADG or F:G in the final three feeding phases. Calves in the SP group had significantly greater ($P = 0.02$) DMI than calves fed FP or FPFM, while calves fed CON and SBM were intermediate.

Over the entire individual feeding

Table 2. Performance of Holstein steers individually fed diets with different sources of RUP in a simulated organic production system

	Dietary Treatment[1]						
Item	CON	FP	FPRM	SBM	SP	SEM	*P*-Value
Phase 1, d1 to d63							
Initial BW, lb	466[a]	470[ab]	471[b]	469[ab]	471[b]	1.3	0.03
d63 BW, lb	556[a]	581[b]	587[b]	585[b]	591[b]	7.9	0.03
ADG, lb/d	1.44[a]	1.77[ab]	1.84[ab]	1.85[ab]	1.91[b]	0.116	0.04
DMI, lb	14.9	14.3	14.4	14.9	15.6	0.46	0.20
F:G	10.75[a]	8.06[b]	7.81[b]	8.13[b]	8.19[b]	-	<0.01
Phases 2–4, d63 to d214							
d63 BW, lb	556[a]	581[b]	587[b]	585[b]	591[b]	7.9	0.03
Final BW, lb	874	892	921	931	938	25.1	0.25
ADG, lb/d	2.29	2.27	2.27	2.25	2.38	0.165	0.97
DMI, lb	20.1[ab]	18.1[a]	18.3[a]	19.0[ab]	21.4[b]	0.77	0.02
F:G	8.93	8.00	8.13	8.55	8.93	-	0.43
Overall, d1 to d214							
Initial BW, lb	466[a]	470[ab]	471[b]	469[ab]	471[b]	1.3	0.03
Final BW, lb	874	892	921	931	938	25.1	0.25
ADG, lb/d	1.91	1.97	2.10	2.16	2.18	0.115	0.28
DMI, lb	19.6[ab]	17.6[a]	17.6[a]	19.1[ab]	20.5[b]	0.73	0.02
F:G	10.20	8.92	8.33	8.85	9.35	-	0.06

Note: Means within a row with different superscripts are different ($P \leq 0.05$)

[1]CON = Control, FP = Field Peas, FPFM = Field Peas + Fish Meal, SBM = Soybean Meal, SP = SoyPass

Table 3. Feed cost of gain of Holstein steers individually fed diets with different sources of RUP in a simulated organic production system

	Dietary Treatment[1]						
Item	CON	FP	FPFM	SBM	SP	SEM	*P*-Value
Feed cost, $/ton DM[2]	336.15	414.69	439.93	462.14	348.10	-	-
Total feed cost, $/head	703.58[a]	778.62[a]	799.34[a]	934.65[b]	761.72[a]	32.751	<0.01
Live weight gain, lb/head	409	422	449	462	467	24.6	0.28
Increase in live weight gain, %[3]	-	3.2	9.8	13.0	14.2	-	-
Cost of gain, $/lb	1.75[ab]	1.91[ab]	1.80[ab]	2.06[b]	1.63[a]	0.089	<0.01

Note: Means within a row with different superscripts are different ($P \leq 0.05$)

[1]CON = Control, FP = Field Peas, FPFM = Field Peas + Fish Meal, SBM = Soybean Meal, SP = SoyPass

[2]Organic feed prices: Dry Rolled Corn = $386.43/ton DM with 2% shrink, Alfalfa Haylage = $257.77/ton DM with 15% shrink, Soybean Meal = $1,020.30/ton DM with 2% shrink, Field Peas = $622.40/ton DM with 5% shrink, Fish Meal = $1,933.80/ton DM with 5% shrink, SoyPass = $580.94/ton DM with 2% shrink, Supplement = $152.78/ton DM with 2% shrink

[3]Percent increase in live weight gain compared to calves fed the Control diet

period, in spite of significant differences in initial BW, protein inclusion and RUP source had no effect ($P \geq 0.25$) on final BW or ADG. Dietary treatment did have a significant impact ($P = 0.02$) on DMI with the SP group having the highest DMI and the FP and FPFM groups having the lowest DMI; Calves fed CON and SBM were intermediate in DMI. This difference in DMI resulted in a tendency ($P = 0.06$) for protein inclusion to affect F:G; calves fed FPFM were the most efficient while those fed CON, FP, SBM, and SP were not different.

An economic analysis is included in Table 3, comparing feed costs of gain (COG) for each dietary treatment. Steers fed SBM had the highest total fed cost ($P < 0.01$) with all other treatments being similar. Live weight gained was not different ($P = 0.28$) between treatments but steers fed SBM also had the highest COG ($P < 0.01$) with those fed SP having the lowest COG and the CON, FP, and FPFM groups being intermediate. It is important to note the soybean meal used in this study was solvent extracted and had an RUP content of approximately 30% of CP, while organic soybean meal is expeller pressed and has a greater RUP content at approximately 59% of CP (Schumacher, *2020 Nebraska Beef Cattle Report*, pp. 45–49). If organic soybean meal were fed at inclusions similar to SoyPass, supplementing organic soybean meal would result in a COG of $1.67 per pound.

Conclusion

These data suggest RUP source has a minimal impact on the performance of lightweight Holstein steers. Supplementing RUP to steers fed a diet of 30% alfalfa haylage resulted in up to 14.2% more live weight gained compared to steers fed no RUP. These data indicate a degree of flexibility in formulating least-cost diets for lightweight Holstein calves in an organic production system. However, if protein sources become too expensive, acceptable results can be obtained without supplementing RUP if 30% of the forage is alfalfa or another feed providing similar dietary protein.

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