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Effects of Added Dietary Protein and Fat on Subcutaneous Adipose Tissue and Longissimus Muscle Fatty Acid Profiles of Finishing Lambs when Fed Differing Levels of Dried Distillers Grains with Solubles

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Summary

The objective of this study was to determine the effects of added dietary protein, fat, and dried distillers grains with solubles (DDGS) on longissimus muscle (LM) and subcutaneous (SQ) adipose fatty acid (FA) profiles in feedlot lambs. Sixty crossbred lambs (29.2 ± 4.6 kg) were allotted into pairs (1 ewe and 1 wether) and fed one of five dietary treatments in individual-pair pens: 1) a corn based diet with 25% DDGS included to meet CP requirements (CON), 2) 50% DDGS (50DDGS), 3) CON with added corn protein in the form of gluten meal to equal the CP in the 50DDGS diet (CON+CP), 4) CON with added vegetable oil to equal the crude fat in the 50DDGS diet (CON+VO), and 5) CON with corn protein and vegetable oil added to equal the CP and crude fat in the 50DDGS diet (CON+CPVO). Thirty wether lambs were utilized to determine differences in the fatty acid profiles of SQ adipose and LM tissues due to dietary treatment. Lambs fed increasing levels of dietary fat had greater (P = 0.04) 18:2*trans*-10, *cis*-12 concentrations in SQ adipose compared with CON lambs. Lambs fed diets with elevated CP and fat had lesser (P = 0.05) concentrations of 18:3n-6 in SQ adipose compared with CON lambs. Lambs fed diets with elevated fat had greater (P = 0.03) concentrations of 18:2*trans*-10, *cis*-12 than CON lambs. Data suggested that diets with elevated fat supply greater concentrations of CLA for biohydrogenation in SQ adipose and LM tissue of feedlot lambs.

Key Words: Dried Distillers Grains with Solubles, Fatty Acid Profiles, Feedlot Lambs

Introduction

Dried distillers grains with solubles (DDGS) have become an alternative to corn in the diets of livestock. Huls et al. (2006) reported that feeding lambs a diet containing either 23% DDGS or 10% soybean meal did not affect performance or carcass characteristics, except for a reduction in backfat thickness. However, Ham et al. (1994) reported that ADG, DMI, and G:F was greater for finishing steers fed diets containing up to 40% DDGS than steers fed a control diet containing dry-rolled corn.

Dried distillers grains with solubles contain approximately 10% fat, whereas dry corn grain contains approximately 4% fat (NRC, 2000). The increase in corn oil, which is high in monounsaturated fatty acids (FA), in the DDGS may alter the FA profile of the longissimus muscle (LM) and subcutaneous (SQ) adipose tissues of lambs. However, due to biohydrogenation of unsaturated FAs in the rumen, the FA composition of the LM tissue and SQ adipose tissue is more difficult to predict (Wood and Enser, 1997). According to Vander Pol et al. (2009), greater proportions of 18:1 *trans*, 18:1, and 18:2 FA reached the duodenum in cattle fed wet distillers grains with solubles compared with cattle consuming a corn-based control diet (Vander Pol et al., 2009). By wet distillers grains with solubles altering the flow of FA to the duodenum, this could lead to changes in the fatty acid profile of the meat.

Little information is available on how elevated levels of DDGS affect performance and carcass quality in finishing lambs. Likewise, it is also unclear as to how an increased level of dietary unsaturated fat from DDGS might affect tissue FA profile. Therefore, the objective was to determine effects of dietary protein and fat on the FA profile of lambs when feeding DDGS.

Materials And Methods

Animals and diets

The Purdue University Animal Care and Use Committee approved all animal handling procedures for this study. Sixty crossbred lambs (29.2 ± 4.6 kg; 30 ewes and 30 wethers) were stratified by BW and allotted into one of five dietary treatments (Table 1): 1) a corn-based diet with DDGS included to meet crude protein (CP) requirements of finishing lambs (25% of DM; CON), 2) CON with DDGS included at twice the amount of CON (50% of DM; 50DDGS), 3) CON with added protein to equal the CP level in the 50DDGS diet (CON+CP), 4) CON with added vegetable oil to equal the crude fat level of the 50DDGS diet (CON+VO), and 5) CON with protein and vegetable oil added to equal that of the CP and fat levels of the 50DDGS diet (CON+CPVO). Thirty wether lambs

Table 1. Dietary ingredients, chemical composition, and FA content of diets fed to feedlot lambs.

	Dietary Treatments[1]				
Item, % of DM	**CON**	**50DDGS**	**CON+CP**	**CON+VO**	**CON+CPVO**
Ingredients					
Dry-rolled corn	59.4	34.2	48.4	48.5	37.7
Dried distillers grains with solubles	25.7	51.2	25.7	25.8	25.8
Ground hay	10.7	10.4	10.6	10.7	10.7
Corn gluten meal	—	—	11.1	—	10.4
Soybean hulls	—	—	—	8.3	8.4
Vegetable oil	—	—	—	2.5	2.8
Molasses	1.2	1.2	1.2	1.2	1.2
Supplement[2]	3.0	3.0	3.0	3.0	3.0
Analyzed composition					
DM, %	89.7	90.5	90.5	90.6	90.6
CP	14.6	18.5	20.3	15.5	19.8
NDF	21.7	24.2	20.5	25.1	23.3
Crude fat	3.5	6.0	4.6	6.3	7.0
ADF	11.7	14.2	12.9	15.4	16.1
Fatty acid, mg/g of DM feed[3]					
Palmitic acid	10.11	11.89	8.36	11.68	11.15
Stearic acid	1.57	1.91	1.29	2.51	2.40
Oleic acid	16.84	20.15	13.78	19.66	18.67
Linoleic acid	40.34	47.81	34.03	50.29	48.51
α-Linolenic acid	1.39	1.76	1.26	3.79	3.80
22:2	0.19	0.24	0.19	0.21	0.22
Other	1.64	1.96	1.43	2.57	2.39
Total	72.03	85.67	60.32	90.65	87.08

[1] CON: 25% DDGS; 50DDGS: 50% DDGS; CON+CP: control diet + corn protein; CON+VO: control diet + vegetable oil; CON+CPVO: control diet + both corn protein and vegetable oil.

[2] Supplement included 150 mg·head^{-1}·d^{-1} thiamin to help prevent sulfur toxicity.

[3] Fatty acid numerical definition: palmitic acid – 16:0, stearic acid – 18:0, oleic acid – 18:1*cis*-9, linoleic acid – 18:2*cis*-9, *cis*-12, and α-Linolenic – 18:3n-3.

Table 2. Effects of differing levels of CP and dietary fat from dried distillers grains with solubles on FA intake (g/d) of feedlot lambs.

	Dietary Treatment[1]						*P*-value[2]		
Fatty acid, g of FA/d[3]	CON	50DDGS	CON+CP	CON+VO	CON+CPVO	SEM	PRO	FAT	PF
Number of lambs	6	5	6	6	6				
Palmitic acid	11.42	12.04	8.70	13.45	11.44	0.39	0.10	0.04	0.43
Stearic acid	1.77	1.93	1.34	2.89	2.46	0.07	0.10	<0.001	<0.001
Oleic acid	19.03	20.40	14.33	22.64	19.16	0.65	0.14	0.02	0.46
Linoleic acid	45.60	48.43	35.39	57.92	49.78	1.62	0.54	0.001	0.57
α-Linolenic acid	1.57	1.79	1.31	4.36	3.90	0.10	<0.001	<0.001	<0.001
SFA	13.26	14.04	10.06	16.39	13.94	0.46	0.25	0.005	0.95
MUFA	19.03	20.40	14.33	22.64	19.16	0.65	0.14	0.02	0.46
PUFA	47.38	50.45	36.90	62.52	53.90	1.73	0.87	<0.001	0.24
Other	2.06	2.23	1.68	3.20	2.67	0.08	0.15	<0.001	<0.001
Total	81.41	86.77	62.73	104.39	89.36	2.91	0.57	0.001	0.51

[1] CON: 25% DDGS; 50DDGS: 50% DDGS; CON+CP: control diet + corn protein; CON+VO: control diet + vegetable oil; CON+CPVO: control diet + both corn protein and vegetable oil.

[2] PRO: CON vs. average of elevated CP diets (50DDGS, CON+CP, and CON+CPVO); FAT: CON vs. average of elevated fat diets (50DDGS, CON+VO, and CON+CPVO); PF: CON vs. both elevated CP and fat diets (50DDGS and CON+CPVO).

[3] Fatty acid numerical definition: palmitic acid – 16:0, stearic acid – 18:0, oleic acid – 18:1*cis*-9, linoleic acid – 18:2*cis*-9, *cis*-12, and α-Linolenic – 18:3n-3.

were utilized to determine differences in the fatty acid profiles of SQ adipose and longissimus muscle (LM) tissues due to dietary treatment. As reported in a companion paper (Van Emon et al., 2012), diets were formulated to determine if differences in performance and carcass quality were associated with feeding increased concentrations of DDGS, dietary CP, dietary fat, or a synergistic effect of both CP and dietary fat. All lambs were supplemented with 150 mg/d thiamin to help prevent sulfur toxicity.

Lambs were vaccinated (Clostridium Perfringens Type C & D with Tetanus Toxoid; Boehringer Ingelheim Pharmaceuticals, Inc.; Ridgefield, CT) prior to the study at 6 wk of age and a booster was given 21 d later. Lambs were stratified by weight and blocked into pairs of one ewe and one wether (6 pens/treatment) and housed in a 1.83-m x 1.83-m pens on a mesh wire floor inside of a curtain-sided building. Three lambs (1 wether and 2 ewes) were removed from the study due to non-treatment related illness and the remaining single lambs were retained in their original pens for the remainder or the trial. Feed was offered *ad libitum* once daily at 0800 and lambs had free access to water. Feed refusals were collected twice weekly and weighed to determine DMI of the pen.

Ewe and wether lamb feedlot performance and carcass characteristics are reported in the companion paper (Van Emon et al., 2012) and the purpose of the present study is to present wether lamb fatty acid characteristics. Wether lambs were selected for harvest when they reached an approximate 12th rib fat depth of 0.5 cm. Upon harvest of wether lambs, the ewe lamb pen mate was returned to the university flock. Lambs were harvested at a common 12th rib fat depth to determine differences in carcass characteristics due to increased dietary levels of CP, crude fat, or both.

Sampling and Laboratory Analysis

Dietary samples were dried in a forced air oven for 48 h at 60°C for DM determination. Samples were then ground to pass a 1-mm screen and composited on an equal dry weight basis. Diets were analyzed for N (Leco model FP2000, Leco Instruments Inc., St. Joseph, MI) using the combustion method (AOAC, 2000; method 990.03) with EDTA as the standard. Feed NDF and ADF was analyzed by an ANKOM$^{200/220}$ Fiber Analyzer (ANKOM Technology, Macedon, NY), and crude fat analyzed by a standard method (AOAC, 2000; method 934.01).

Longissimus muscle and SQ adipose tissue samples were collected after a 24-h chill from the 12th to 13th rib interface and stored at -20°C for FA analysis. Subcutaneous adipose tissue was removed from the LM tissue prior to freeze-drying and stored at -20°C for FA analysis. Longissimus muscle samples were freeze-dried and ground using a coffee bean grinder.

Fatty acid analysis of the diets was accomplished using an acid catalyst (HCl) direct-*trans* esterification method of Kucuk et al. (2001). Subcutaneous adipose and LM tissue samples were analyzed using an alkaline catalyst (KOH). Preparation of the SQ adipose and LM tissues was according to procedures outlined by Murrieta et al. (2003). LM tissue consists of freeze dried LM with subcutaneous fat removed prior to freeze-drying. Each sample contained 1 mg of Methyl tridecanoic acid (T-0627, Sigma-Aldrich, St. Louis MO).

Fatty acid concentrations were determined by gas chromatography (Model 3800, Varian Inc., Palo Alto, CA; Appendix F) using a 100-m capillary column (Supelco 2560, Supelco, Bellefonte, PA). Hydrogen was the carrier gas and was maintained at a column flow of 1.5 mL/min. The oven temperature was maintained at 120°C for 2 min, ramped up to 175°C at a 6°C/min interval, and finally to 250°C at a 10°C/min interval. Injector temperature was held

at 260°C while detector temperature was held at 300°C. The split-ratio for the LM tissue was 30:1 and 100:1 for SQ adipose tissue. Purified FA standards (Sigma-Aldrich, St. Louis, MO; Nu-Check Prep, Elysian, MN, Matreya, Pleasant Gap, PA) were used to identify individual peaks. Fatty acids will presented as mg FA/g of diet DM (Table 1), g of FA/d (Table 2), mg of FA/g of SQ adipose tissue (Table 3) or mg of FA/g of LM tissue (Table 4; includes intermuscular fat extracted from lean muscle).

Statistical Analysis

Response variables included fatty acid intake and fatty acid composition of adipose tissue and longissimus muscle and were individually analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). The model statement included the fixed effect of treatment and individual lamb served as the experimental unit for FA analysis. Single-degree of freedom orthogonal contrasts were then used to test treatment effects: 1) CON diet vs. average of the diets containing elevated CP levels (50DDGS, CON+CP, and CON+CPVO; PRO), 2) CON diet vs. average of the diets containing elevated fat levels (50DDGS, CON+VO, and CON+CPVO; FAT), and 3) CON diet vs. average of the diets containing both elevated CP and fat levels (50DDGS and CON+CPVO; PF).

Results

Fatty Acid Intake

Daily FA intake is located in Table 2. Dry matter intake was reported previously in Van Emon et al. (2012). Lambs consuming the FAT diets had greater ($P \leq 0.04$) intake of all FA, which led to an increase in total FA ($P = 0.001$) compared with the lambs fed CON. Lambs consuming FAT, PRO, and PF had greater ($P < 0.001$) intakes of -linolenic acid than CON lambs. Additionally, FAT and PF had greater ($P < 0.001$) intakes of stearic acid than CON.

Subcutaneous Adipose

Total FA concentrations of SQ adipose tissue were similar ($P \geq 0.52$) between all dietary treatments (Table 3). Lambs fed FAT had greater ($P = 0.04$) concentrations of 18:2*trans*-10, *cis*-12 in SQ adipose vs. lambs fed CON. Lambs fed CON had greater ($P \leq 0.05$) concentrations of 18:3n-6 in SQ adipose than all other dietary treatments. Lambs consuming FAT tended to have increased levels of vaccenic acid ($P = 0.06$), linoelaidic acid ($P = 0.08$), and the CLA iso-

Table 3. Effects of differing levels of CP and dietary fat from dried distillers grains with solubles on subcutaneous adipose tissue FA profile in feedlot lambs.

	Dietary Treatment[1]						*P*-value[2]		
Fatty Acid, mg/g of adipose tissue[3]	CON	50DDGS	CON+CP	CON+VO	CON+CPVO	SEM	PRO	FAT	PF
Number of lambs	6	5	6	6	6				
Myristic acid	15.27	14.35	14.94	15.66	15.80	1.73	0.90	1.00	0.99
Myristoleic acid	0.38	0.39	0.73	0.53	0.43	0.19	0.50	0.72	0.26
Palmitic acid	126.99	123.55	143.47	123.48	124.34	8.11	0.69	0.71	0.48
Palmitoleic acid	10.89	10.43	11.13	11.36	10.27	0.76	0.74	0.81	0.68
Stearic acid	104.59	93.08	116.97	80.43	104.67	12.32	0.98	0.37	0.67
Vaccenic acid	74.81	95.22	54.97	110.85	103.69	13.69	0.51	0.06	0.60
Oleic acid	200.72	191.14	228.28	188.67	181.34	12.03	0.97	0.30	0.57
cis-Vaccenic acid	7.41	8.10	8.31	8.27	7.59	0.72	0.45	0.47	0.29
Linoelaidic acid	0.46	0.43	0.54	1.01	1.14	0.21	0.28	0.08	0.19
Linoleic acid	42.47	51.96	46.83	35.26	34.61	4.59	0.69	0.71	0.78
CLA – 18:2*trans*-10, *cis*-12	0.53	0.96	0.55	0.61	0.68	0.09	0.06	0.04	0.64
CLA – 18:2*cis*-9, *trans*-11	3.19	3.68	3.32	3.43	4.39	0.31	0.07	0.06	0.59
γ-Linolenic acid	0.14	0.07	0.08	0.04	0.01	0.03	0.02	0.01	0.05
α-Linolenic acid	2.37	2.51	2.07	2.76	2.62	0.22	0.90	0.28	0.86
SFA	267.41	250.01	294.59	237.88	263.33	18.01	0.92	0.38	0.95
MUFA	299.63	310.87	309.03	325.24	308.12	18.54	0.79	0.49	0.41
PUFA	49.68	60.06	54.60	43.62	43.91	4.80	0.79	0.49	0.92
Other	49.84	51.30	52.23	51.32	61.45	7.62	0.53	0.56	0.82
Total	639.58	647.19	684.42	633.68	653.04	9.00	0.52	0.88	0.59

[1] CON: 25% DDGS; 50DDGS: 50% DDGS; CON+CP: control diet + corn protein; CON+VO: control diet + vegetable oil; CON+CPVO: control diet + both corn protein and vegetable oil.

[2] PRO: CON vs. average of elevated CP diets (50DDGS, CON+CP, and CON+CPVO); FAT: CON vs. average of elevated fat diets (50DDGS, CON+VO, and CON+CPVO); PF: CON vs. both elevated CP and fat diets (50DDGS and CON+CPVO).

[3] Fatty acid numerical definition: myristic acid – 14:0, myristoleic acid – 14:1, palmitic acid – 16:0, palmitoleic acid – 16:1, stearic acid – 18:0, vaccenic acid – 18:1*trans*-11, oleic acid – 18:1*cis*-9, *cis*-vaccenic acid – 18:1*cis*-11, linoelaidic acid – 18:2*trans*-9, *trans*-12, linoleic acid – 18:2*cis*-9, *cis*-12, γ-linolenic acid – 18:3n-6, and α-Linolenic – 18:3n-3.

Table 4. Effects of differing levels of CP and dietary fat from dried distillers grains with solubles on longissimus muscle tissue FA profile of feedlot lambs.

	Dietary Treatment[1]						*P*-value[2]		
Fatty Acid, mg of fatty acid/g of LM tissue[3]	CON	50DDGS	CON+CP	CON+VO	CON+CPVO	SEM	PRO	FAT	PF
Number of lambs	6	5	6	6	6				
Lauric acid	0.12	0.07	0.06	0.13	0.08	0.02	0.03	0.22	0.30
Myristic acid	2.28	1.47	1.46	2.68	1.83	0.37	0.09	0.48	0.62
Myristoleic acid	0.02	0.02	0.00	0.07	0.02	0.02	0.76	0.44	0.47
Palmitic acid	23.52	16.46	19.20	26.19	19.68	3.50	0.19	0.47	0.83
Palmitoleic acid	1.88	1.11	1.25	2.15	1.36	0.30	0.06	0.30	0.60
Stearic acid	14.42	10.20	13.14	15.30	13.00	2.04	0.30	0.47	0.93
Vaccenic acid	6.98	6.85	3.68	12.49	9.25	2.19	0.87	0.28	0.66
Oleic acid	41.17	24.98	31.91	42.36	30.82	6.35	0.09	0.22	0.58
cis-vaccenic acid	1.84	1.30	1.34	2.05	1.43	0.23	0.06	0.32	0.58
Linoleic acid	10.80	10.64	9.93	10.81	9.31	0.73	0.29	0.49	0.60
CLA – 18:2*trans*-10, *cis*-12	0.00	0.03	0.00	0.04	0.03	0.01	0.17	0.03	0.21
CLA – 18:2*cis*-9, *trans*-11	0.46	0.35	0.35	0.58	0.54	0.08	0.59	0.75	0.97
α-Linolenic acid	0.44	0.34	0.29	0.57	0.43	0.06	0.16	0.88	0.92
SFA	42.84	29.94	35.65	46.82	36.37	6.01	0.18	0.43	0.81
MUFA	55.01	37.07	40.96	62.08	45.20	8.83	0.15	0.47	0.73
PUFA	12.26	11.87	11.03	12.57	10.82	0.82	0.25	0.56	0.62
Other	7.91	5.49	5.30	7.04	5.25	0.84	0.01	0.04	0.08
Total	111.85	79.30	87.92	122.46	93.03	15.60	0.14	0.42	0.71

[1] CON: 25% DDGS; 50DDGS: 50% DDGS; CON+CP: control + corn protein; CON+VO: control + vegetable oil; CON+CPVO: control + both corn protein and vegetable oil.

[2] PRO: CON vs. average of elevated CP diets (50DDGS, CON+CP, and CON+CPVO); FAT: CON vs. average of elevated fat diets (50DDGS, CON+VO, and CON+CPVO); PF: CON vs. both elevated CP and fat diets (50DDGS and CON+CPVO).

[3] LM tissue consists of freeze dried LM with subcutaneous fat removed prior to freeze-drying. Fatty acid numerical definition: lauric acid – 12:0, myristic acid – 14:0, myristoleic acid – 14:1, palmitic acid – 16:0, palmitoleic acid – 16:1, stearic acid – 18:0, vaccenic acid – 18:1*trans*-11, oleic acid – 18:1*cis*-9, *cis*-vaccenic acid – 18:1*cis*-11, linoleic acid – 18:2*cis*-9, *cis*-12, and α-Linolenic – 18:3n-3.

mer 18:2*cis*-9, *trans*-11 ($P = 0.06$) in SQ adipose compared with lambs consuming the CON diet. Lambs consuming PRO tended to have greater concentrations of the CLA isomers 18:2*cis*-9, *trans*-11 ($P = 0.07$) and 18:2*trans*-10, *cis*-12 ($P = 0.06$) concentrations vs. lambs fed CON. No differences were observed ($P \geq 0.19$) in the other FA in SQ adipose tissue due to dietary treatment.

Longissimus Muscle

Total FA concentrations in the LM tissue (intermuscular fat extracted from lean muscle) were similar ($P \geq 0.14$; Table 4) across dietary treatments. The lambs fed the elevated PRO had less concentrations of lauric acid ($P = 0.03$) and tended to have less concentrations of myristic acid ($P = 0.09$), palmitoleic acid ($P = 0.06$), oleic acid ($P = 0.09$), and *cis*-vaccenic acid ($P = 0.06$) in LM tissue than lambs fed CON. Lambs consuming the FAT diets had greater ($P = 0.03$) concentrations of the CLA isomer 18:2*trans*-10, *cis*-12 in LM tissue than lambs consuming CON. Concentrations of other FA in LM tissue were less for PRO ($P = 0.01$) and FAT ($P = 0.04$) and tended to be reduced for lambs consuming the PF ($P = 0.08$) diet vs. lambs fed CON. No differences were observed ($P \geq 0.15$) in the other FA in LM tissue due to dietary treatments.

Discussion

The major FA found in adipose tissue are myristic, palmitic, stearic, and oleic acids, which constitutes approximately 80% of the FAs in adipose tissue depots in ruminants (Byers and Schelling, 1988). Subcutaneous adipose FA concentrations from lambs in the current study agree with Byers and Schelling (1988). In the current study, there were relatively low concentrations of both 18:3n-3 and 18:3n-6 in the SQ adipose tissue. This may suggest that biohydrogenation was occurring in the rumen and branched chain FA are being hydrogenated to a more saturated form. Rapid biohydrogenation of FA is expected in lambs consuming diets containing vegetable oil as it is a more readily available source of FA than a protected FA source, such as DDGS, to rumen microbes (Jenkins and Bridges, 2007).

Increasing unsaturated FA composi-

tion of SQ adipose and LM tissues is difficult, primarily due to rumen microbial biohydrogenation of FA (Wood and Enser, 1997). Complete biohydrogenation of linoleic acid results in the saturated FA stearic acid (Jenkins et al., 2008). In the current study, greater concentrations of biohydrogenation intermediates, vaccenic and linoelaidic acids, in the SQ adipose tissue of lambs fed the high-fat diets (50DDGS, CON+VO, and CON+CPVO) were likely due to a reduction in complete ruminal biohydrogenation. The tendency of the elevated fat diets on the intermediates was driven by the diets containing the vegetable oil (CON+VO and CON+CPVO). Results observed from feeding beef cattle DDGS by Lancaster et al. (2007) also suggest that PUFA from the oil fraction of DDGS may be partially protected from ruminal biohydrogenation. Greater proportions of 18:1 *trans*, 18:1, and 18:2 FA reached the duodenum in cattle fed wet distillers grains with solubles compared with cattle consuming a corn-based control diet (Vander Pol et al., 2009). However, based on the current results, the deposition of linoleic acid biohydrogenation intermediates and stearic acid in the LM and SQ adipose tissue does not appear to be greatly altered by the inclusion of DDGS, CP, or fat.

Contrary to the current results, Price et al. (2007) observed that lambs fed safflower seeds, both whole and cracked, had greater duodenal flow of biohydrogenation intermediates, suggesting less complete biohydrogenation. However, Scollan et al. (2001) reported that when whole linseed was fed to steers, the seed coat provided little protection for PUFA from ruminal biohydrogenation. Duodenal flow of linoleic acid biohydrogenation intermediates were also increased in those lambs fed extracted safflower oil (Price et al., 2007). Bartoň et al. (2007) also observed greater concentrations of CLA in SQ fat in heifers that were fed a linseed-supplemented diet. The results reported here suggest that the extent of biohydrogenation was similar across all diets due to the similar concentrations of stearic acid in both the SQ adipose and LM tissues. However, Castillo-Lopez et al. (2013) suggested that intake of unsaturated FA was greater when cattle consumed DDGS compared with corn bran, which appeared to stimulate rumen biohydrogenation and increased the flow of saturated FA to the duodenum. According to Drackley (2000), the majority of the CLA produced in the rumen was most likely hydrogenated to vaccenic acid, and ultimately to stearic acid. Despite this, the current study did not observe any differences across dietary treatments in stearic acid concentrations, which would again suggest a similar extent of biohydrogenation across dietary treatments.

It has previously been concluded that increased concentrations of linoleic acid in the ration may reduce biohydrogenation in the rumen and therefore increase the flow of unsaturated FA to the small intestine (Beam et al., 2000). Although the lambs fed the added fat diets (50DDGS, CON+VO, and CON+CPVO) had increased dietary intake of linoleic acid, there was no effect on the extent of biohydrogenation in those lambs. Additionally, two different sources of fat were fed, DDGS or vegetable oil, and neither had an effect on concentrations of linoleic acid biohydrogenation intermediates.

Conclusion

Dried distillers grains with solubles has become an widely used feed for ruminants as both a protein and energy source. The increased fat and protein in DDGS does alter FA intake, but ultimately had little impact on the extent of biohydrogenation. Furthermore, diets containing both fat and/or protein had little effect on the FA concentrations of feedlot lambs. Additionally, feeding growing lambs a diet up to 50% DDGS has little effect on the FA composition of both SQ adipose and LM tissues. Fatty acid composition also had little impact on the growth and carcass characteristics measured (Van Emon et al., 2012). Therefore, more research needs to be conducted as to why feedlot cattle may be more affected by DDGS than feedlot lambs.

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