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Fatty Acid Composition of Beef from Cattle Fed Wet Distillers Grains Diets Supplemented with Vitamin E

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Summary

Crossbred yearlings (n = 90) were allotted to one of ten diets containing 0%, 20% and 40% wet distillers grains (WDG) with or without vitamin E supplementation and distillers solubles. Strip loin and tenderloin steaks were obtained and tested for their fatty acid profiles using gas chromatography. WDG diets increased linearly (P < 0.05) the polyunsaturated fatty acids (PUFA) containing 18 or more carbons and trans fatty acids in both muscles. No significant differences were found for total saturated and unsaturated fatty acids. Dietary inclusion of neither vitamin E nor distiller solubles significantly changed PUFA, trans, omega-6 or omega-3 fats in strip loins and tenderloins. Therefore, changes in the fatty acid profile of beef are a consequence of WDG, not the solubles or vitamin E.

Introduction

Fresh beef containing high levels of polyunsaturated fatty acids (PUFA) decreases shelf life by diminishing color and consumer appeal. In addition, compounds produced from oxidation of PUFA give undesirable flavors to beef, thereby making them less attractive to the consumer. Vitamin E (E) is an antioxidant that can easily be incorporated into animal tissues via feeding. Previous studies have shown that vitamin E supplementation mitigates oxidation and thereby increases shelf life of meat (Senaratne et al. *2009 Nebraska Beef Report*, pp. 113-115).

De Mello et al. (*2008 Nebraska Beef Report*, pp. 108-109) showed elevated PUFA in beef from yearlings fed wet distillers grain plus solubles up to 30%. It is unknown if fatty acid changes occur as a result of the distillers solubles or the WDG themselves. Therefore, the aim of the current study was to determine the effect of feeding vitamin E with 0%, 20% and 40% WDG (DM basis) with or without solubles on the fatty acid profile of strip loin and tenderloin muscles.

Procedure

Ninety crossbred steers (n = 336) were randomly allotted to one of six diets containing 0%, 20% or 40% WDG (DM basis) with or without E supplementation (500 IU of α-tocopherol acetate/steer daily). Vitamin E was fed the last 100 days. Distillers solubles also were added to 20% and 40% WDG diets with or without E at ratios of 100:0 and 70:30 (WDG to distillers solubles) to create four additional diets. Diets containing distillers solubles were named high soluble (H) diets, whereas diets containing no distillers solubles were named low soluble (L) diets. Composition of these diets is presented by Godsey et al. (*2009 Nebraska Beef Report*, pp. 59-61). Steers were fed for a total of 140 days and slaughtered at Greater Omaha Packing Co. (Omaha, Neb.). After grading, short loins from 90 carcasses (10 from each treatment – 5 USDA Choice and 5 USDA Select) were vacuum-packed, transported under refrigeration to Loeffel Meat Laboratory at the University of Nebraska-Lincoln and aged for 7 and 28 days at 32 to 36°F. After fabrication, strip loins (m. *Longissimus lumborum)* and tenderloins (m. *Psoas major*) were sliced into 1-inch thick steaks. Steaks of each sample were immediately vacuum-packaged and stored at -4°F to avoid oxidation. Each steak was diced, pulverized after dipping in liquid nitrogen, stored at -112°F and tested for fatty acid composition. Total lipid of each sample was extracted with chloroform:methanol (2:1, v/v) solvent. The extracted lipid was converted to fatty acid methyl esters, and fatty acids were separated by gas chromatography using a capillary column, which was placed in an oven programmed from 284°F to 428°F at a rate of 3.6°F/minute. The injector and detector were programmed to work at 518°F and 512°F, respectively. Each lipid extraction was separated into fatty acids by using helium as the carrier gas at a flow rate of 30 mL/minute. Individual fatty acids of each sample were determined by comparing retention times with known standards.

An analysis of variance using the GLIMMIX procedure of SAS (version 9.1, Cary, N.C., 2002) was used to analyze the data as a 2 x 3 x 2 factorial design (absence or presence of E and solubles and three levels of WDG). Significant means of main effects ($P < 0.05$) were separated using LS-MEANS. When there was no interaction, linear and quadratic effects of WDG on each fatty acid were tested.

Results

Most of the significant effects on fatty acid composition came from the distillers grains. Very few effects were due to level of solubles and vitamin E. Diets did not significantly influence the total saturated (SFA) and unsaturated fatty acid (UFA) contents of strip loin and tenderloin steaks ($P > 0.05$). Diets significantly decreased the myristoleic (C14:1), palmitoleic (C16:1) and *cis*-10 heptadecenoic (C17:1) fatty acid contents in strip loin and tenderloin steaks (Tables 1 and 2). In addition, monounsaturated fatty acids (MUFA [C18:1 Δ6-9*t*, C18:1 Δ10*t*, C18:1 Δ11*t*, C18:1 Δ13*t*, and C18:1 Δ14*t*] and PUFA [C18:2 Δ9*t*, 12*t*, C18:2 (n-6), and C18:3 (n-3)]) containing 18 or more carbons were found at significantly higher levels in strip loin and tenderloin steaks from cattle fed 20% or 40% WDG than in steaks from cattle fed 0% WDG diets (Tables 1 and 2).

Table 1. Main effects of WDG, solubles, vitamin E and their interactions on mean weight percentage of total fatty acids[a] of strip loin (m. *Longissimus lumborum*) from steers fed with WDG with or without vitamin E and solubles .

Vitamin E	Supplemented with E					Non-supplemented with E					*P*-value			
%WDG + Sol	0	20 L	20 H	40 L	40 H	0	20 L	20 H	40 L	40 H	E	WDG	Sol	E x WDG x Sol
C10:0	0.01	0.00	0.00	0.20	0.00	0.01	0.00	0.02	0.20	0.02	0.08	0.27	0.94	0.86
C12:0	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.02	0.0008	0.57	0.003	0.39
C14:0	2.85	2.60	2.88	2.99	2.82	3.13	2.47	3.04	2.89	3.03	0.35	0.16	0.16	0.97
C14:1	0.73	0.61	0.64	0.60	0.55	0.83	0.52	0.59	0.55	0.58	0.07	0.01*	0.26	0.70
C15:0	0.52	0.42	0.49	0.42	0.46	0.53	0.43	0.53	0.46	0.44	0.56	0.01*	0.10	0.37
iso C16:0	0.61	0.52	0.56	0.59	0.72	0.61	0.60	0.60	0.50	0.54	0.42	0.59	0.27	0.42
C16:0	26.35	22.68	25.61	25.10	25.39	26.73	23.05	25.62	25.71	25.26	0.82	0.07	0.17	0.92
C16:1	3.21	2.35	2.78	2.47	2.61	3.49	2.41	2.87	2.41	2.48	0.64	<.0001**	0.06	0.85
C17:0	1.50	1.25	1.42	1.12	1.28	1.40	1.23	1.40	1.31	1.18	0.60	0.01*	0.19	0.31
iso C18:0	0.44	0.41	0.45	0.52	0.61	0.45	0.51	0.49	0.44	0.45	0.60	0.53	0.43	0.89
C17:1	1.36	0.99	1.18	0.83	1.00	1.30	0.99	1.15	0.94	0.92	0.67	<.0001*	0.03	0.46
C18:0	13.62	12.94	13.98	14.98	14.06	13.38	12.92	14.25	15.31	15.26	0.58	0.07	0.58	0.82
C18:1 Δ6-9*t*	0.44	0.50	0.54	0.65	0.73	0.50	0.50	0.43	0.61	0.65	0.41	0.0003*	0.63	0.67
C18:1 Δ10*t*	1.84	1.80	2.22	2.41	3.53	1.61	1.81	2.01	2.03	3.07	0.17	0.0007*	0.001	0.88
C18:1 Δ11*t*	0.45	0.58	0.59	1.86	0.46	0.34	0.68	0.46	1.28	0.96	0.96	0.002*	0.03	0.13
C18:1	40.98	35.00	39.26	35.98	37.22	39.90	34.79	39.10	37.47	36.75	0.86	0.04*	0.13	0.73
C18:1(*n-7*)	0.63	0.39	0.58	0.72	0.65	0.53	0.44	0.56	0.58	0.62	0.36	0.04**	0.24	0.50
C18:1 Δ13*t*	0.02	0.08	0.13	0.25	0.21	0.08	0.09	0.12	0.17	0.27	0.48	<.0001*	0.18	0.16
C18:1 Δ14*t*	0.00	0.00	0.02	0.12	0.07	0.00	0.03	0.01	0.06	0.09	0.96	0.0003*	0.96	0.10
C19:0	0.02	0.03	0.10	0.12	0.07	0.04	0.01	0.06	0.08	0.13	0.99	0.01*	0.13	0.10
C18:2 Δ9*t*, 12*t*	0.01	0.01	0.04	0.07	0.05	0.01	0.00	0.03	0.05	0.10	0.72	0.001*	0.11	0.13
C18:2	2.43	3.79	3.66	5.52	4.90	2.69	4.01	3.74	4.55	4.60	0.68	<.0001*	0.30	0.39
C20:0	0.01	0.01	0.03	0.05	0.01	0.04	0.01	0.04	0.06	0.07	0.62	0.05	0.12	0.91
C18:3	0.05	0.05	0.10	0. 15	0.09	0.08	0.07	0.11	0.09	0.17	0.15	0.02*	0.13	0.06
CLA *c*9, *t*11	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.02	0.01	0.00	0.38	0.71	0.91	0.72
C20:1	0.04	0.27	0.46	0.48	0.46	0.43	0.39	0.39	0.40	0.480	0.94	0.05	0.08	0.03
C20:2	0.00	0.000	0.02	0.00	0.00	0.00	0.00	0.000	0.01	0.00	0.70	0.083	0.91	0.91
C20:3	0.21	0.16	0.23	0.21	0.27	0.18	0.24	0.23	0.22	0.23	0.86	0.62	0.106	0.71
C20:4	0.75	0.71	0.78	0.84	0.96	0.76	0.84	0.81	0.79	0.72	0.54	0.70	0.71	0.670
Others	1.00	0.87	0.86	0.90	0.83	1.03	0.70	1.29	0.89	0.84	0.35	0.23	0.20	0.12

*Linear relationship between levels of WDG vs. a particular fatty acid.
**Quadratic relationship between levels of WDG vs. a particular fatty acid.
[a]Weight percentage values are relative proportions of all peaks observed by gas chromatography.
SOL = distillers solubles.
CLA = conjugated linoleic acids.

There was a significant increase in trans fat isomers of oleic acid (C18:1) and linoleic acid (C18:2) in strip loin and tenderloin steaks when cattle were fed with WDG diets (Tables 1 and 2), due to the action of rumen microorganisms on unsaturated fats present in the WDG diets, thereby making more trans fats. Moreover, PUFA:SFA, omega-6 (n-6), omega-3 (n-3), and (n-6):(n-3) in strip loins and tenderloins significantly increased with the increasing levels of WDG in the diet (Table 2). However, there were significant differences in MUFA of tenderloin steaks (Table 3). MUFA were significantly higher in tenderloin steaks from cattle fed 0% WDG diets compared to steaks from animals fed 20% or 40% WDG diets.

The effect of vitamin E supplementation on fatty acid profiles of strip loin and tenderloins was not significant for any fatty acids except lauric acid (C12:0). However, there was a significant main effect of vitamin E on unsaturated fats in tenderloins (Table 3). Moreover, solubles in diets significantly increased *cis*-10 heptadecenoic (C17:1) in both strip loin and tenderloins (Table 1 & 2). Neither vitamin E nor solubles showed any significant effect on the levels of PUFA, trans, omega-6 or omega-3 fats of strip loins and tenderloins (Table 2).

As a whole, the presence or absence of vitamin E had few effects on the fatty acids profile of both strip loin and tenderloin. Therefore, results of this study showed that WDG diets significantly increased trans fats and PUFA containing 18 or more carbons in tenderloins and strip loins. The PUFA are liable to oxidize easily and thereby cause detrimental effects on color and sensory attributes of beef.

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Table 2. Main effects of WDG, solubles, vitamin E and their interactions on mean weight percentage of total fatty acids[a] of tenderloins (m. *Psoas major*) from steers fed with WDG with or without vitamin E and solubles

Vitamin E	Supplemented with E					Non-supplemented with E					*P*-value			
%WDG + Sol	0	20 L	20 H	40 L	40 H	0	20 L	20 H	40 L	40 H	E	WDG	Sol	E x WDG x Sol
C10:0	0.01	0.02	0.02	0.05	0.01	0.01	0.02	0.28	0.02	0.02	0.22	0.50	0.32	0.33
C12:0	0.01	0.01	0.01	0.02	0.01	0.03	0.02	0.05	0.02	0.02	0.007	0.74	0.32	0.49
C14:0	2.78	2.68	2.86	2.72	2.58	3.06	2.56	2.90	2.68	2.76	0.23	0.05	0.19	0.86
C14:1	0.66	0.57	0.57	0.52	0.45	0.70	0.52	0.59	0.55	0.58	0.10	0.0003*	0.83	0.81
C15:0	0.55	0.49	0.51	0.46	0.49	0.56	0.51	0.53	0.49	0.47	0.47	0.002*	0.59	0.40
iso C16:0	0.54	0.55	0.55	0.52	0.66	0.61	0.55	0.48	0.56	0.60	0.92	0.38	0.50	0.89
C16:0	25.70	24.65	25.19	24.52	24.52	26.33	25.22	25.23	24.93	24.50	0.22	0.001*	0.69	0.83
C16:1	2.53	2.02	2.11	1.82	1.98	2.67	1.95	2.14	1.77	1.91	0.90	< .0001**	0.06	0.70
C17:0	1.49	1.40	1.45	1.15	1.29	1.40	1.44	1.43	1.33	1.22	0.71	< .0001**	0.62	0.16
iso C18:0	0.41	0.46	0.45	0.49	0.46	0.48	0.49	0.40	0.50	0.53	0.44	0.31	0.46	0.33
C17:1	1.06	0.84	0.94	0.60	0.87	1.05	0.85	0.85	0.71	0.72	0.23	< .0001*	0.009	0.28
C18:0	15.48	16.84	16.76	17.59	16.52	15.70	17.46	14.91	17.86	17.44	0.95	0.006*	0.06	0.15
C18:1 Δ6-9*t*	0.39	0.57	0.43	0.52	0.65	0.46	0.43	0.51	0.51	0.56	0.62	0.16	0.38	0.23
C18:1 Δ10*t*	1.92	1.98	1.86	3.82	3.10	1.84	2.34	2.07	2.34	2.67	0.13	< .0001*	0.53	0.09
C18:1 Δ11*t*	0.98	1.33	1.13	1.29	1.53	0.54	1.14	1.33	1.62	1.96	0.95	0.0086*	0.32	0.85
C18:1	37.70	36.30	35.97	33.14	34.47	36.93	35.67	35.93	34.00	33.99	0.48	< .0001*	0.47	0.27
C18:1(*n-7*)	0.43	0.34	0.44	0.65	0.68	0.42	0.30	0.43	0.54	0.49	0.30	0.01**	0.44	0.71
C18:1 Δ13*t*	0.21	0.24	0.24	0.27	0.24	0.20	0.25	0.25	0.24	0.25	0.69	0.04*	0.94	0.43
C18:1 Δ14*t*	0.11	0.17	0.16	0.23	0.17	0.09	0.15	0.17	0.16	0.18	0.35	0.003*	0.64	0.53
C19:0	0.01	0.01	0.01	0.13	0.06	0.01	0.02	0.07	0.06	0.04	0.83	0.002*	0.51	0.95
C18:2 Δ9*t*, 12*t*	0.10	0.15	0.13	0.17	0.15	0.09	0.13	0.13	0.13	0.17	0.49	0.02*	0.95	0.52
C18:2	3.28	4.8	4.20	5.85	5.50	3.14	4.29	3.84	5.22	5.16	0.09	< .0001*	0.11	0.94
C20:0	0.08	0.11	0.07	0.16	0.08	0.06	0.14	0.12	0.12	0.11	0.35	0.001*	0.004	0.42
C18:3	0.20	0.21	0.20	0.24	0.21	0.20	0.21	0.21	0.22	0.23	0.65	0.18	0.38	0.55
CLA *c*9, *t*11	0.02	0.03	0.02	0.03	0.02	0.02	0.03	0.03	0.02	0.02	0.85	0.45	0.71	0.78
C20:1	0.58	0.55	0.55	0.62	0.61	0.57	0.59	0.55	0.52	0.63	0.73	0.41	0.52	0.13
C20:2	0.02	0.01	0.02	0.07	0.02	0.01	0.02	q0.02	0.04	0.04	0.97	0.12	0.33	0.26
C20:3	0.22	0.24	0.24	0.26	0.23	0.20	0.25	0.22	0.27	0.27	0.72	0.02*	0.19	0.26
C20:4	0.84	0.84	0.86	0.84	1.00	0.84	0.85	0.76	0.93	0.89	0.55	0.29	0.83	0.71

*Linear relationships between levels of WDGS vs. a particular fatty acid at $P < 0.05$.
**Quadratic relationship between levels of WDGS vs. a particular fatty acid at $P < 0.05$.
[a]Weight percentage values are relative proportions of all peaks observed by gas chromatography.
SOL = distillers solubles.
CLA = conjugated linoleic acids.

Table 3. Main effects of WDG, solubles, vitamin E and their interactions on mean weight percentage of total significant ($P < 0.05$) fatty acids[a] of strip loin (M. *longissimus lumborum*) and tenderloins (M. *psoas major*) from steers fed with WDG with or without vitamin E and solubles

Vitamin E	Supplemented with E					Non-supplemented with E					*P*-value			
%WDG + Sol	0	20 L	20 H	40 L	40 H	0	20 L	20 H	40 L	40 H	E	WDG	Sol	E x WDG x Sol
Strip loin														
SFA	46.32	41.15	45.97	46.38	45.86	46.73	41.62	46.45	47.19	46.86	0.69	0.14	0.20	0.98
UFA	53.05	47.32	53.15	53.20	53.74	52.67	47.85	53.06	52.31	52.77	0.83	0.21	0.13	0.94
MUFA	49.60	42.59	48.32	46.40	47.48	48.95	42.68	48.11	46.59	46.96	0.86	0.07	0.08	0.96
PUFA	3.45	4.72	4.83	6.80	6.26	3.73	5.17	4.95	5.73	5.81	0.72	< .0001*	0.62	0.41
trans	2.92	3.37	4.06	6.12	5.70	0.02	3.55	3.88	4.77	5.76	0.62	< .0001*	0.28	0.24
(*n-6*)	3.39	4.66	4.67	6.57	6.12	3.62	5.10	4.78	5.56	5.54	0.64	< .0001*	0.52	0.52
(*n-3*)	0.05	0.05	0.10	0.15	0.09	0.08	0.07	0.11	0.09	0.17	0.15	0.02*	0.13	0.06
(*n-6*)/(*n-3*)	28.95	31.19	29.25	36.14	33.82	24.57	33.86	31.64	32.88	33.23	0.40	< .0001*	0.13	0.46
PUFA/SFA	0.08	0.12	0.11	0.15	0.14	0.08	0.13	0.09	0.12	0.03	0.09	< .0001*	0.03	0.06
Tenderloin														
SFA	51.26	51.36	50.56	50.94	51.85	50.16	49.96	49.99	49.97	50.69	0.33	0.92	0.21	0.28
UFA	51.26	51.36	50.56	50.94	51.85	50.16	49.96	49.99	49.97	50.69	0.01	0.61	0.61	0.55
MUFA	46.58	45.01	44.89	43.48	44.74	45.66	44.18	44.77	43.15	43.92	0.07	< .0001*	0.09	0.42
PUFA	4.69	6.36	5.67	7.46	7.11	4.50	5.78	5.22	6.82	6.77	0.13	< .0001*	0.15	0.88
trans	4.17	4.93	4.90	6.97	6.53	3.85	4.77	4.87	5.75	6.28	0.25	< .0001*	0.90	0.51
(*n-6*)	4.34	5.95	5.30	6.95	6.73	4.18	5.39	4.82	6.42	6.32	0.14	< .0001*	0.18	0.97
(*n-3*)	0.20	0.21	0.20	0.24	0.21	0.20	0.21	0.21	0.22	0.23	0.65	0.18	0.38	0.56
(*n-6*)/(*n-3*)	21.42	28.25	26.93	29.52	28.75	20.69	25.65	23.44	29.11	27.94	0.14	< .0001*	0.24	0.92
PUFA/SFA	0.10	0.14	0.12	0.16	0.15	0.09	0.12	0.12	0.14	0.14	0.15	< .0001*	0.36	0.84

*Linear relationships between levels of WDGS vs. a particular fatty acid.
**Quadratic relationship between levels of WDGS vs. a particular fatty acid.
[a]Weight percentage values are relative proportions of all peaks observed by gas chromatography.
SOL = distillers solubles.