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Fatty Acid Profile of Three Beef Muscles from Yearlings and Calf-Fed Steers Fed Wet Distillers Grains Plus Solubles

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Summary

Two experiments were conducted to analyze the effects of wet distillers grains plus solubles (WDGS) finishing diets on the fatty acid profile of beef. Ribeye slices (m. Longissimus thoracis*), tenderloins (m.* Psoas major*), and top blades (m.* Infraspinatus*) were analyzed. Calf-fed (Experiment 1) and yearling steers (Experiment 2) (n = 96 each) were allocated into three treatments of 0%, 15% or 30% WDGS (DM basis) for each experiment. For all muscles, polyunsaturated fatty acid (PUFA) levels were higher in beef from animals fed 30% WDGS. Except in tenderloins in Experiment 1, trans fatty acids increased linearly with level of WDGS in the diet. In addition, feeding WDGS increased all trans 18:1 fatty acid isomers except delta 14, which decreased. Feeding WDGS changes the fatty acid profile of beef, which has implications for color stability and shelf life.*

Introduction

Fatty acid profile may influence color, oxidation and flavor of beef. Polyunsaturated fatty acids (PUFA) may support higher oxidation and have detrimental effects on color (*2008 Nebraska Beef Report*, pp. 108-109), which may decrease shelf life and cause economic losses. Research conducted by Jenschke et al. (*2007 Nebraska Beef Report*, pp. 84-85) demonstrated that changes in fatty acid profile in beef can be related to liver-like off-flavor of beef.

Beef contains more trans fatty acids than lamb, pork and poultry. This type of fat is produced via biohydrogenization by microorganisms in the rumen. Although 90% of trans fat consumed by the population comes from non-meat industrialized products, beef contains trans fatty acids such as elaidic (18:1*t*, n-9) and conjugated linoleic acid (CLA).

Research has demonstrated that WDGS has a positive influence on animal performance (Bremer et al., *2008 Nebraska Beef Report*, pp. 33-34). The aim of this research was to identify the effects of finishing diets containing WDGS on the fatty acid profile of beef.

Procedure

Two similar experiments were conducted using 96 steers each. In Experiment 1, calf-fed crossbred steers were allocated to three different finishing diets with 0%, 15%, or 30% WDGS (DM basis) and fed for 133 days. In Experiment 2, yearling crossbred steers were allocated to the same treatments and fed for 115 days. Diet composition was based on dry-rolled corn, high-moisture corn, alfalfa hay and WDGS (Luebbe et al., *2008 Nebraska Beef Report*, pp. 53-55).

For both experiments, a 0.25-in thick ribeye slice (m. *Longissimus thoracis*) was excised from each carcass at the 12th rib and transferred under refrigeration to the Loeffel Meat Laboratory at the University of Nebraska. In addition, 48 carcasses were randomly selected by grade among the 96 (16 per treatment, 8 Choice and 8 Select); the shoulder clods (IMPS #114) and short loins (IMPS #174) were removed, vacuum-packaged and transferred to the University of Nebraska Meat Laboratory. After seven days aging at 39°F, the tenderloins (m. *Psoas major*) and the top blades (m. *Infraspinatus*) were fabricated from the short loins and shoulder clods, respectively. One, 1-inch thick steak was cut from each tenderloin and top blade. Steaks and the ribeye slice were trimmed, submerged in liquid N, pulverized and stored at -112°F until the fatty acids analysis could be made.

For fatty acid analysis, total lipid was extracted according to Folch et al. (1957, *Journal of Biological Chemistry 226*:497-509), converted to methyl esters (1964, *Journal of Lipid Research 5*:600-608; 1966, *Analytical Chemistry 38*:514-515), analyzed by gas chromatography and separated through a capillary column. Oven temperature was set at 284°F to 428°F, rising 3.6°F/minute. Oven temperature was held at 428°F, whereas the temperature of the injector was set at 518°F. During the analysis, the detector was set at 572°F and helium was used as a gas carrier. Fatty acids were identified by comparing the retention times with standards. Additionally in Experiment 1, levels of each 18:1 trans delta isomer, such as 6-8, 9, 10, 11, 13 and 14, from tenderloins and top blades were analyzed.

For each experiment, data were analyzed separately. The statistical analysis was conducted using SAS (Version 9.1, Cary, N.C., 2002) as a completely randomized design where animal was the experimental unit. Analysis of variance (ANOVA) using the GLIMMIX procedure was conducted with an alpha level of 0.05. Means were separated using the LSMEANS and identified using DIFF and LINES. Linear and quadratic relationships for all fatty acids and contrasts comparison for trans delta isomers were verified using the MIXED procedure.

Results

Level of PUFA increased linearly as level of WDGS increased for top blades (Table 1), tenderloins (Table 2) and strip loins (Table 3). The major component of PUFA, linoleic acid (18:2, n-6), increased in a linear or quadratic fashion in all cases (Tables 1-3). This result was in agreement with our hypothesis: higher levels of WDGS would increase PUFA. Similar results

(Continued on next page)

Table 1. Weight percentage of fatty acids[1] of top blade (m. *Infraspinatus*) from calf-fed and yearling steers affected by finishing diets containing WDGS.

	Dietary treatments[2]											
	Calf-fed						Yearling					
Fatty acids	0%	15%	30%	*P*	Linear[3]	Quadratic[3]	0%	15%	30%	*P*	Linear[3]	Quadratic[3]
14:1 (n-5)	0.63^{ab}	0.70^{a}	0.52^{b}	0.01	0.06	0.02	0.71	0.60	0.62	0.16	0.14	0.23
15:0	0.50^{ab}	0.56^{a}	0.47^{b}	0.03	0.45	0.01	0.49	0.48	0.47	0.90	0.64	0.96
16:0	25.06^{a}	24.26^{ab}	23.48^{b}	< 0.01	0.01	0.97	22.17	22.21	22.64	0.42	0.24	0.55
16:1(n-7)	3.12^{a}	2.93^{a}	2.46^{b}	< 0.01	< 0.01	0.27	3.26^{a}	2.94^{b}	2.69^{b}	< 0.01	< 0.01	0.84
17:0	1.54^{ab}	1.68^{a}	1.39^{b}	0.05	0.19	0.03	1.56	1.62	1.51	0.63	0.72	0.37
17:1(n-7)	1.21^{a}	1.24^{a}	1.00^{b}	< 0.01	0.01	0.06	1.42^{a}	1.33^{a}	1.04^{b}	0.02	< 0.01	0.36
18:1*t*	2.17^{b}	2.79^{b}	4.03^{a}	< 0.01	< 0.01	0.29	2.25^{c}	2.80^{b}	4.14^{a}	< 0.01	< 0.01	0.08
18:1(n-9)	38.46	37.37	36.52	0.06	0.02	0.86	40.72^{a}	39.68^{a}	37.57^{b}	< 0.01	< 0.01	0.46
18:1(n-7)	1.73^{a}	1.58^{b}	1.47^{b}	< 0.01	< 0.01	0.80	2.11^{a}	1.93^{b}	1.67^{c}	< 0.01	< 0.01	0.39
18:1Δ13t	0.08^{c}	0.23^{b}	0.37^{a}	< 0.01	< 0.01	0.95	0.15^{c}	0.24^{b}	0.35^{a}	< 0.01	< 0.01	0.51
18:1Δ14*t*	0.38^{a}	0.38^{a}	0.28^{b}	< 0.01	< 0.01	0.08	0.49^{a}	0.40^{b}	0.37^{b}	0.02	< 0.01	0.42
18:2(n-6)	3.00^{c}	3.96^{b}	4.78^{a}	< 0.01	< 0.01	0.82	2.76^{c}	3.63^{b}	4.43^{a}	< 0.01	< 0.01	0.91
22:5	0.19^{a}	0.13^{ab}	0.10^{b}	0.03	0.01	0.70	0.25	0.24	0.24	0.76	0.54	0.86
Omega 6	4.24^{b}	5.07^{b}	6.10^{a}	< 0.01	< 0.01	0.80	3.91^{b}	4.84^{a}	5.62^{a}	< 0.01	< 0.01	0.84
Total trans	4.36^{b}	4.98^{b}	6.15^{a}	< 0.01	< 0.01	0.37	5.12^{b}	5.37^{b}	6.41^{a}	< 0.01	< 0.01	0.08
PUFA	4.60^{b}	5.38^{ab}	6.40^{a}	< 0.01	< 0.01	0.81	4.37^{b}	5.33^{ab}	6.09^{a}	< 0.01	< 0.01	0.81

[1]Weight percentage values are relative proportions of all peaks observed by GC.
[2]Wet distillers grains plus solubles.
[3]Linear and quadratic response to MWDGS level.
[a,b,c]Means in the same row within age groups having different superscripts are significant at $P \leq 0.05$ level.

were found by de Mello Jr. et al. (*2008 Nebraska Beef Report*, pp. 108-109) and Gill et al. (2008, *Journal of Animal Science 86*:923-935). Polyunsaturated fatty acids have weak double bonds between carbon atoms, making the molecule easier to oxidize. Oxidation of lipids is directly proportional to the oxidation of myoglobin pigment, which produces undesirable color and rancid flavor. Consequently, beef quality is compromised when high oxidation occurs.

For both age groups and all muscles, values of vaccenic fatty acid (18:1, n-7) were lower when animals were fed 30% WDGS. Camfield et al. (1997, *Journal of Animal Science 75*:1837-1844) reported that a reduction in this fatty acid is related to increases in liver, soured and metallic flavors.

In our study, there were positive, linear relationships between level of WDGS fed and total trans fatty acids for all muscles, except for tenderloins from calf-fed steers. A linear or quadratic response was identified for two 18:1 delta-trans isomers (18:1Δ13*t* and 18:1Δ14*t*). Generally, values of delta-13 increased and values of delta-14 decreased. Vander Pol et al. (*2007 Nebraska Beef Report*, pp. 39-42) showed that the major component of the trans fatty acid group found in beef, elaidic fatty acid (18:1*t*, n-9), is identified in high levels at the duodenum when WDGS is supplied to cattle.

For monounsaturated fatty acids, values of palmitoleic acid (16:1, n-7) linearly decreased for most muscles

Table 2. Weight percentage of fatty acids[1] of tenderloin (m. *Psoas major*) from calf-fed and yearling steers affected by finishing diets containing WDGS.

	Dietary treatments[2]											
	Calf-fed						Yearling					
Fatty acids	0%	15%	30%	*P*	Linear[3]	Quadratic[3]	0%	15%	30%	*P*	Linear[3]	Quadratic[3]
14:1 (n-5)	0.64^{ab}	0.70^{a}	0.57^{b}	0.04	0.21	0.03	0.69^{a}	0.59^{ab}	0.55^{b}	0.03	< 0.01	0.65
16:0	26.36^{a}	25.45^{ab}	24.62^{b}	< 0.01	< 0.01	0.09	23.99	23.79	23.66	0.65	0.36	0.90
16:1(n-7)	2.59^{a}	2.53^{a}	2.06^{b}	< 0.01	< 0.01	0.09	2.86^{a}	2.46^{b}	2.15^{c}	< 0.01	< 0.01	0.68
17:1(n-7)	0.98	0.90	0.78	0.10	0.03	0.83	1.22^{a}	1.12^{a}	0.92^{b}	< 0.01	< 0.01	0.46
18:0	15.64	15.46	16.58	0.15	0.12	0.22	14.57^{b}	15.24^{ab}	15.56^{b}	0.03	0.01	0.57
18:1*t*	1.30	2.09	1.72	0.56	0.57	0.37	2.86^{c}	3.75^{b}	4.88^{a}	< 0.01	< 0.01	0.72
18:1(n-9)	35.31^{a}	34.55^{a}	33.12^{b}	< 0.01	< 0.01	0.56	37.27^{a}	35.98^{a}	33.69^{b}	< 0.01	< 0.01	0.46
18:1 (n-7)	1.43^{a}	1.37^{ab}	1.26^{b}	0.01	< 0.01	0.62	1.76^{a}	1.57^{b}	1.41^{c}	< 0.01	< 0.01	0.83
18:1Δ13*t*	0.17^{c}	0.27^{b}	0.41^{a}	< 0.01	< 0.01	0.20	0.31	0.30	0.24	0.08	0.03	0.50
18:1Δ14*t*	0.26^{a}	0.28^{a}	0.21^{b}	< 0.01	0.05	0.01	0.13	0.14	0.13	0.90	0.91	0.67
18:2(n-6)	3.08^{c}	4.07^{b}	4.80^{a}	< 0.01	< 0.01	0.66	3.04^{c}	3.84^{b}	5.05^{a}	< 0.01	< 0.01	0.38
18:3(n-3)	0.22	0.23	0.23	0.72	0.54	0.60	0.23^{b}	0.25^{b}	0.28^{a}	< 0.01	< 0.01	0.44
22:5	0.20^{a}	0.17^{ab}	0.15^{b}	0.03	0.01	0.78	0.28	0.25	0.28	0.56	0.83	0.30
Omega 6	4.34^{b}	5.23^{ab}	6.05^{a}	< 0.01	< 0.01	0.92	4.33^{b}	5.08^{b}	6.43^{a}	< 0.01	< 0.01	0.37
Total trans	3.20	4.05	3.66	0.59	0.52	0.33	5.26^{b}	5.94^{b}	6.75^{a}	< 0.01	< 0.01	0.84
PUFA	4.79^{b}	5.68^{ab}	6.48^{a}	< 0.01	< 0.01	0.91	4.95^{b}	5.68^{b}	7.11^{a}	< 0.01	< 0.01	0.33

[1]Weight percentage values are relative proportions of all peaks observed by GC.
[2]Wet distillers grains plus solubles.
[3]Linear and quadratic response to MWDGS level.
[a,b,c]Means in the same row within age groups having different superscripts are significant at $P \leq 0.05$ level.

Table 3. Weight percentage of fatty acids[1] of ribeyes (m. *Longissimus thoracis*) from calf-fed and yearling steers affected by finishing diets containing WDGS

	Dietary treatments[2]											
	Calf-fed						Yearling					
Fatty acids	0%	15%	30%	*P*	Linear[3]	Quadratic[3]	0%	15%	30%	*P*	Linear[3]	Quadratic[3]
14:1 (n-5)	0.64[a]	0.63[a]	0.54[b]	0.04	0.25	0.09	0.74	0.67	0.68	0.41	0.09	0.40
Iso 16:0	0.93	0.90	0.81	0.22	0.43	0.27	0.68[a]	0.56[b]	0.65[a]	0.05	0.98	0.36
16:0	26.35[a]	25.83[ab]	25.12[b]	< 0.01	0.29	0.13	24.14	24.08	24.33	0.81	0.72	0.98
16:1(n-7)	3.50[a]	3.23[b]	2.90[c]	< 0.01	0.29	0.11	3.46[a]	2.97[b]	2.81[b]	< 0.01	< 0.01	0.13
17:0	1.43[b]	1.66[a]	1.43[b]	0.01	0.15	< 0.01	1.47	1.60	1.43	0.10	0.12	0.03
Iso 18:0	0.66	0.73	0.64	0.24	0.54	0.01	0.44[ab]	0.37[b]	0.50[a]	0.04	0.16	0.05
17:1(n-7)	1.08[ab]	1.17[a]	0.98[b]	0.03	0.79	< 0.01	1.26[a]	1.21[a]	1.03[b]	< 0.01	< 0.01	0.14
18:0	13.76[b]	14.13[b]	15.03[a]	0.02	< 0.01	0.33	13.02	13.64	13.28	0.44	0.99	0.47
18:1*t*	2.28[b]	2.61[b]	3.76[a]	< 0.01	< 0.01	0.35	2.59[b]	3.74[a]	4.23[a]	< 0.01	< 0.01	0.54
18:1(n-9)	36.14[a]	34.66[b]	34.02[b]	< 0.01	0.46	0.20	36.89	37.82	36.35	0.46	0.09	0.49
18:1(n-7)	3.20[a]	2.77[b]	2.41[c]	< 0.01	0.02	0.13	1.83[a]	1.56[b]	1.44[c]	< 0.01	< 0.01	0.12
18:1Δ13*t*	0.10[c]	0.51[b]	0.64[a]	< 0.01	< 0.01	< 0.01	0.15[c]	0.27[b]	0.33[a]	< 0.01	< 0.01	0.48
18:1Δ14*t*	0.49	0.48	0.43	0.06	0.88	0.04	0.42[a]	0.37[ab]	0.34[b]	0.01	< 0.01	0.90
18:2*t*	0.003[c]	0.01[b]	0.03[a]	0.01	0.01	0.78	0.02	0.04	0.04	0.24	0.37	0.61
18:2(n-6)	3.27[b]	4.22[a]	4.50[a]	< 0.01	< 0.01	0.04	2.19[c]	3.25[b]	4.15[a]	< 0.01	< 0.01	0.58
20:3	0.29[b]	0.33[ab]	0.35[a]	0.05	< 0.01	< 0.01	0.28	0.25	0.29	0.30	0.14	0.25
Omega 6	4.62[b]	5.60[a]	5.86[a]	< 0.01	< 0.01	0.47	3.81[c]	4.53[b]	5.71[a]	< 0.01	< 0.01	0.69
Total trans	2.87[c]	3.61[b]	4.86[a]	< 0.01	< 0.01	0.33	3.17[b]	4.43[a]	4.94[a]	< 0.01	< 0.01	0.53
PUFA	4.90[b]	5.91[a]	6.23[a]	< 0.01	< 0.01	0.29	4.23[b]	4.91[b]	6.15[a]	< 0.01	< 0.01	0.60

[1]Weight percentage values are relative proportions of all peaks observed by GC.
[2]Wet distillers grains plus solubles.
[3]Linear and quadratic response to MWDGS level.
[a,b,c]Means in the same row within age groups having different superscripts are significant at $P \leq 0.05$ level.

Table 4. Weight percentage of trans-delta 18:1 isomers fatty acids [1] of tenderloin (m. *Psoas major*) from calf-fed steers affected by finishing diets containing WDGS.

	Dietary treatments[2]				Contrast[4]		
18:1 trans	0%	15%	30%	*P*	Linear[3]	Quadratic[3]	0 x WDGS
Δ6-8	0.26[b]	0.31[b]	0.42[a]	< 0.01	< 0.01	0.40	< 0.01
Δ9	0.32	0.29	0.37	0.40	0.45	0.23	0.97
Δ10	1.49[b]	1.91[b]	2.82[a]	< 0.01	< 0.01	0.31	< 0.01
Δ11	0.78[b]	0.86[b]	1.18[a]	< 0.01	< 0.01	0.06	< 0.01
Δ13	0.17[c]	0.27[b]	0.41[a]	< 0.01	< 0.01	0.20	< 0.01
Δ14	0.26[a]	0.28[a]	0.21[b]	< 0.01	0.05	0.01	0.66

[1]Weight percentage values are relative proportions of all peaks observed by GC.
[2]Wet distillers grains plus solubles.
[3]Linear and quadratic response to MWDGS level.
[4]Contrast comparison (0% x 15 and 30%WDGS).
[a,b,c]Means in the same row within age groups having different superscripts are significant at $P \leq 0.05$ level.

Table 5. Weight percentage of trans-delta 18:1 isomers fatty acids [1] of top blade (m. *Infraspinatus*) from calf-fed steers affected by finishing diets containing WDGS.

	Dietary treatments[2]				Contrast[4]		
18:1 trans	0%	15%	30%	*P*	Linear[3]	Quadratic[3]	0 x WDGS
Δ6-8	0.20	0.25	0.31	0.06	< 0.01	0.75	0.03
Δ9	0.22[b]	0.29[b]	0.40[a]	< 0.01	< 0.01	0.41	< 0.01
Δ10	1.24[b]	1.67[b]	2.48[a]	< 0.01	< 0.01	0.32	< 0.01
Δ11	0.53[c]	0.66[b]	0.83[a]	< 0.01	< 0.01	0.45	< 0.01
Δ13	0.08[c]	0.23[b]	0.37[a]	< 0.01	< 0.01	0.95	< 0.01
Δ14	0.38[a]	0.38[a]	0.28[b]	< 0.01	< 0.01	0.08	0.15

[1]Weight percentage values are relative proportions of all peaks observed by GC.
[2]Wet distillers grains plus solubles.
[3]Linear and quadratic response to MWDGS level.
[4]Contrast comparison (0% x 15 and 30%WDGS).
[a,b,c]Means in the same row within age groups having different superscripts are significant at $P \leq 0.05$ level.

and age groups. Except in the longissimus muscle, feeding WDGS also lowered values of oleic acid (18:1, n-9).

Data from Experiment 1 for trans 18:1 isomers are presented in Tables 4 and 5 for tenderloins and top blades, respectively. Significant linear increase in trans-delta isomers of 18:1 fatty acids as a result of increasing WDGS level was observed. Although this relationship was identified, the significance of these changes is unclear, as the impact on human health is still highly questionable despite popular opinion about trans fat (2002, *Science 295*:1464-1466).

In conclusion, feeding WDGS alters the fatty acid profile of beef. The increase of PUFA, Omega 6 and total trans fatty acids was observed in both age groups.

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