PE9.37 Fatty acid profile of beef from steers fed wet distillers grains plus solubles (WDGS) and vitamin E. 293.00

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Abstract: The aim of this work was to investigate the fatty acid profile of m. teres major (TER) and m. infraspinatus (INF) from steers fed 0 or 40% WDGS (DM basis) with or without 500 I.U. of vitamin E/head/d for 100 d. Thirty-two steers were allocated to 4 treatments: Corn, Corn + vit. E, 40% WDGS, or 40% WDGS + vit. E. After 7 d of aging, 2 TER and 2 INF muscles were excised from shoulder clods of eah animal. Fatty acids were analyzed for raw TER and INF, pan fried TER and INF, and grilled INF. For all muscles, higher levels of polyunsaturated and 18:1 trans fatty acids, and lower values of 18:1(n-7) were observed in beef from animals fed WDGS (P < 0.05). Vitamin E supplementation did not affect the fatty acid profile of either muscle. When TER were pan fried and INF were grilled, higher levels of most of the long-chain fatty acids and 18:1(n-9) were observed compared with raw samples. Therefore, feeding WDGS increased polyunsaturated fatty acids and decreased 18:1 (n-7), which may lead to oxidation in raw beef and intensify off flavors, respectively.

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I. INTRODUCTION

In the past few years, a significant increase of ethanol production in the United States led to a higher supply of a milling by-product called Wet Distillers Grains plus Solubles (WDGS). Advantages of feeding WDGS include carcass traits [1] and lower production costs. Most WDGS come from corn produced in the Midwest. This region also has a high concentration of feedlots and is responsible for the largest commercial red meat production [2]. In addition, feedlots are concentrated near to ethanol plants facilitating the distribution of by-products to producers. Feeding WDGS is often practiced during beef cattle finishing in a period that may vary from 100 to 160 days. Although research demonstrated a linear increase of average daily gain, feed conversion, hot carcass weight, and marbling score when steers were fed 40% WDGS [3], feeding 30% WDGS increased polyunsaturated fatty acids (PUFA) in the ribeye (m. longissimus thoracis) [4]. Higher levels of PUFA contribute to higher oxidation, lower shelf life, and off flavor development. Our research was conducted to verify the effects of feeding WDGS and vitamin E supplementation on fatty acid profile of m. teres major (TER) and m. infraspinatus (INF).

II. MATERIALS AND METHODS

A. Treatments, cooking, and fatty acid analysis

Yearling steers (n=32) were allocated to four dietary treatments (Corn, Corn + vit. E, 40% WDGS, or 40% WDGS + vit. E) and fed for 100 d. Vitamin E dose was 500 I.U. /head/d. After 7 d of aging, TER and INF muscles were excised from shoulder clods, trimmed of subcutaneous fat and epimysial connective tissue, and frozen (-16°C) until cooking and fatty acid analysis could be made. Muscles were pan fried (TER and INF) and grilled (INF) until internal temperature reached 71°C. For fatty acid analysis raw and cooked samples were submerged in liquid N, pulverized and stored at -80°C. Total lipid was extracted [5] and converted to fatty acid methyl esters [6,7]. Compounds were analyzed by gas chromatography (Hewlett-Packard Gas Chromatograph - Agilent Technologies, model 6890 series, Santa Clara, CA) and separated using a capillary column (Chrompack CP-Sil 88 (0,25 mm x 100 m). Oven temperature was programmed from 140 to 220°C at 2°C/min and held at 220°C for 20 min. Injector and detector temperature were maintained at 270 and 300°C, respectively. The carrier gas was Helium at a flow rate of 30 mL/min. Fatty acids were identified by comparison of retention times with known standards.

B.Statistical Analysis

Fatty acid profile was arranged on a 4x3 factorial design for INF (4 dietary treatments and 3 cooking procedures: raw, pan fried, and grilled) and on 4x2 factorial for TER (2 cooking procedures: raw and pan fried). Data were analyzed using the GLIMMIX procedure of SAS (Version 9.1, Cary, N.C., 2002). When significance ($P \leq 0.05$) was indicated by ANOVA, means separations were performed using the LSMEANS and DIFF functions of SAS.

II. RESULTS AND DISCUSSION

No interaction of treatment and cooking method and main effect of vitamin E supplementation were observed either for TER or INF ($P > 0.05$). Therefore, muscles were analyzed for treatment differences between raw and within each cooking procedure.

For raw TER samples, feeding WDGS increased levels of 18:0, 18:1 trans, 18:1Δ13, 18:1Δ14, 18:2(n-6), 18:3(n-3), PUFA, ω 6, and ω 3 fatty acids (Table 1), whereas no differences were observed in values of 18:1 trans, 18:2(n-6), 18:3(n-3), PUFA, ω 6, and ω 3 for INF (Table 2). For both muscles, lower levels of 17:1(n-7) and 18:1(n-7) were observed when feeding WDGS.

The PUFA are easier oxidized by factors such as reactive oxygen species and other free radicals. High levels of PUFA in beef are associated with higher values of oxidation and compromised beef color. In addition, oxidation of lipids produces ketones and aldehydes which may affect beef flavor. Higher levels of 18:1 trans fatty acids and 18:0 on raw samples in the lean may be a response of WDGS composition, which has higher lipid content and greater fat digestibility when compared with corn. Conversely, feeding WDGS decreased 17:1(n-7) in both raw muscles and 18:1(n-7) in raw TER. A numeric decrease of 18:1(n-7) in INF was observed and values approached significance ($P = 0.06$).

When cooked (TER pan fried and INF pan fried and grilled), samples from animals fed WDGS showed higher 18:1 trans values and increased PUFA when compared to samples from steers fed corn. In contrast, values of 18:1(n-7) did not differ between cooked muscles from steers fed WDGS and corn.

Higher levels of PUFA in cooked beef may also develop a rancid/oxidized flavor commonly called warmed-over flavor (WOF) when meat is re-heated. Additionally, research showed a negative correlation of off flavor intensity and 18:1(n-7) [8]. Therefore, lower values of this fatty acid in raw muscle from animals fed WDGS may represent a risk to off flavor development.

Regarding cooking effect, grilled INF had higher values of 20:3(n-6), 20:4(n-6), 22:4(n-6), and 22:5(n-3) when compared with raw samples. Similar results were observed in pan fried TER, except for 20:3(n-6). However, no major effects of cooking were observed in other fatty acids.

III. CONCLUSION

Feeding WDGS modifies the fatty acid profile of m. teres major and m. infraspinatus and vitamin E supplementation does not mitigate these changes.

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Table 1. Weight percentage of fatty acids[1] of raw TER from steers fed WDGS and Vitamin E.

	Treatments (% WDGS (DM basis), Vitamin E)					Contrast
Fatty acid	Corn	Corn vit E	40% no vit E	40% vit E	*P* - value	Corn vs WDGS
17:1(n-7)	1.34^{A}	1.36^{A}	0.87^{B}	1.00^{B}	0.0005	<0.0001
18:0	12.39^{B}	12.91^{B}	14.65^{A}	13.71^{AB}	0.01	0.004
18:1 trans	2.35^{B}	2.18^{B}	3.95^{A}	3.79^{A}	<0.0001	<0.0001
18:1(n-9)	39.87^{A}	40.00^{A}	36.83^{B}	36.40^{B}	0.0005	<0.0001
18:1 (n-7)	0.70^{AB}	0.81^{A}	0.50^{C}	0.59^{BC}	0.01	0.002
18:1Δ13	0.06^{B}	0.12^{B}	0.23^{A}	0.14^{B}	0.004	0.005
18:1Δ14	0.08^{C}	0.12^{BC}	0.19^{A}	0.17^{AB}	0.002	0.0006
19:0	0.02	0.00	0.05	0.00	0.09	0.27
18:2(n-6)	3.85^{B}	3.48^{B}	5.88^{A}	5.62^{A}	<0.0001	<0.0001
18:3(n-3)	0.16^{A}	0.12^{B}	0.19^{A}	0.19^{A}	0.004	0.0009
PUFA	5.97^{B}	5.49^{B}	7.87^{A}	7.72^{A}	0.0008	<0.0001
ω 6	5.80^{B}	5.37^{B}	7.68^{A}	7.53^{A}	0.0009	<0.0001
ω 3	0.16^{A}	0.12^{B}	0.19^{A}	0.19^{A}	0.004	0.0009
ω 6 / ω 3	36.00	37.00	40.38	40.39	0.32	0.09

[1] Weight percentage values are relative proportions of all peaks observed by Gas Chromatography.
[A, B] Means in the same row having different superscripts are significant at $P \leq 0.05$ level.

Table 2. Weight percentage of fatty acids[1] raw INF from steers fed WDGS and Vitamin E.

	Treatments (% WDGS (DM basis), Vitamin E)					Contrast
Fatty acid	Corn	Corn vit E	40% no vit E	40% vit E	*P* - value	Corn vs WDGS
17:1(n-7)	1.38^{A}	1.39^{A}	1.00^{B}	0.96^{B}	0.0004	<0.0001
18:0	13.60	13.44	14.75	14.10	0.31	0.10
18:1 trans	2.27^{B}	2.19^{B}	3.41^{AB}	3.68^{A}	0.05	0.01
18:1(n-9)	40.07	41.30	38.83	38.50	0.13	0.03
18:1 (n-7)	0.86^{AB}	0.94^{A}	0.66^{C}	0.73^{BC}	0.03	0.06
18:1Δ13	0.19	0.21	0.23	0.21	0.64	0.30
18:1Δ14	0.17	0.18	0.22	0.20	0.15	0.06
19:0	0.07	0.11	0.14	0.14	0.06	0.02
18:2(n-6)	2.68^{B}	2.41^{B}	4.56^{A}	4.77^{A}	<0.0001	<0.0001
18:3(n-3)	0.15^{B}	0.14^{B}	0.19^{A}	0.21^{A}	<0.0001	<0.0001
PUFA	3.83^{B}	3.55^{B}	5.82^{A}	6.24^{A}	<0.0001	<0.0001
ω 6	3.41^{B}	3.68^{B}	5.63^{A}	6.03^{A}	<0.0001	<0.0001
ω 3	0.15^{B}	0.14^{B}	0.19^{A}	0.21^{A}	<0.0001	<0.0001
ω 6 / ω 3	24.86	24.78	30.11	29.64	0.17	0.03

[1] Weight percentage values are relative proportions of all peaks observed by Gas Chromatography.
[A, B] Means in the same row having different superscripts are significant at $P \leq 0.05$ level.

Table 3. Weight percentage of fatty acids[1] cooked TER and INF from steers fed WDGS and Vitamin E.

		Treatments (% WDGS (DM basis), Vitamin E)					Contrast
Muscle		Corn	Corn vit E	40% no vit E	40% vit E	*P* - value	Corn vs WDGS
Pan fried TER							
	18:1 trans	2.06^{B}	2.30^{B}	4.17^{A}	4.23^{A}	<0.0001	<0.0001
	18:1(n-7)	0.73	0.85	0.59	0.57	0.06	0.01
	PUFA	7.06^{B}	6.27^{B}	8.57^{A}	8.84^{A}	0.002	0.0004
Pan fried INF							
	18:1 trans	2.16^{B}	1.95^{B}	3.84^{A}	3.91^{A}	<0.0001	<0.0001
	18:1(n-7)	0.78	0.96	0.71	0.61	0.07	0.03
	PUFA	4.56^{B}	4.05^{B}	6.09^{A}	6.19^{A}	0.0004	<0.0001
Grilled INF							
	18:1 trans	2.16^{B}	1.98^{B}	3.72^{A}	3.27^{A}	0.01	0.001
	18:1(n-7)	0.86	0.97	0.81	0.74	0.37	0.14
	PUFA	4.73^{B}	4.77^{B}	6.58^{A}	6.78^{A}	0.002	0.0002

[1] Weight percentage values are relative proportions of all peaks observed by Gas Chromatography.
[A,B]Means in the same row within muscle having different superscripts are significant at $P \leq 0.05$ level.