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Wet Distillers Grains Diets Supplemented with Vitamin E Alter the Mineral Composition of Beef m. *longissimus lumborum* and m. *psoas major*

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Summary

Crossbred yearlings (n = 90) were allotted to one of 10 diets containing 0, 20 or 40% wet distillers grains (WDG) with or without vitamin E supplementation and distillers solubles (DS). Strip loin and tenderloin steaks were obtained and tested for their mineral (Ca, P, K, Mg, Zn, Fe, Mn, Cu, S, and Na) compositions using atomic absorption spectroscopy. Cattle fed DS diets had higher ($P \leq 0.05$) levels of Ca, Fe, P, Mn, and S in strip loins than cattle fed non-DS diets. Feeding DS significantly reduced Mg and Na in tenderloins. Neither WDG nor vitamin E diets significantly affected the mineral composition of strip loins and tenderloins. In conclusion, feeding DS altered the mineral composition of strip loins. Changes in the mineral composition of beef are a consequence of dietary inclusion of DS, not WDG or vitamin E.

Introduction

Calkins and Hodgen (2007 *Meat Science, 77:*63-80) mentioned that changes in mineral composition of beef due to different diets may cause off flavors in beef. Yancey et al. (2006 *Meat Science,73:* 680-686) also reported that Fe played a key role in liver-like off-flavors in beef. Moreover, Lawrie (*Meat Science 6th edition,* Woodhead Publishing Ltd, Cambridge, England) mentioned that sulfur-containing compounds were also responsible for off flavors in meat. Jenschke et al. (2007 *Journal of Muscle Foods, 18:*341-348) showed that high levels of Na also caused off flavors in cooked beef. Therefore, it is important to consider how the mineral profile of beef changes with cattle diets.

Dry-milling ethanol production utilizes only the starch portion of the corn distillers grains. All the other nutrients (protein, fat, fiber, minerals, and vitamins) are concentrated about three-fold. The mineral portion of the grain is concentrated in the distillers byproducts in the ethanol production process. Previous studies have shown that feeding wet distillers grains plus distillers solubles (WDG plus DS) increases the level of polyunsaturated fatty acids (PUFA) in the beef and subsequently reduces beef lipid and color stability during retail display (*2009 Nebraska Beef Report*, pp. 110-112; *2008 Nebraska Beef Report*, pp. 108-109). Senaratne et al. (*2009 Nebraska Beef Report*, pp. 113-115 and 116-117) showed that vitamin E (E; α-tocopherol) supplementation suppressed the elevated lipid and pigment oxidation of beef due to WDG ± DS feeding.

However, it is unknown how feeding WDG, DS, and vitamin E affect the mineral composition of beef. Therefore, the aim of the current study was to determine the effect of feeding vitamin E with different levels of WDG, with or without DS, on mineral composition of beef strip loin (m. *longissimus lumborum*) and tenderloin (m. *psoas major*).

Procedure

Ninety crossbred steers (out of 336 total) were randomly selected for one of six diets containing 0, 20, or 40% WDG (DM basis) with or without E supplementation (500 I.U. of α-tocopherol acetate/steer daily) beyond the basal diet. Vitamin E was fed for the last 100 days. Distillers solubles also were added to 20 and 40% WDG diets with or without E at a ratio of WDG to DS of 100:0 and 70:30 to create four additional diets. Diets containing DS were named as high soluble [H] diets whereas diets containing no DS were named as low soluble [L] diets. Composition of these diets was 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 days at 32 to 36ºF. 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 -4ºF. Each steak was diced, pulverized after dipping in liquid nitrogen, stored at -112ºF and tested for mineral (Ca, P, K, Mg, Zn, Fe, Mn, Cu, S, and Na) composition using atomic adsorption spectroscopy at a commercial laboratory (Ward Laboratories, Inc., Kearney, Neb.). The Ca, P, K, Mg, S, and Na were expressed as percentages, and Zn, Fe, Mn, and Cu were expressed as ppm on a dry matter basis.

An analysis of variance (ANOVA) using the GLIMMIX procedure of SAS (version 9.1, Cary, N.C., 2002) was used to analyze the data as two factorial designs. Analysis I dealt with data from all low DS diets containing 0, 20, or 40% WDG with or without E supplementation and analyzed them as a 2 × 3 factorial design (three levels of WDG – 0, 20, and 40%, and two levels of E supplementation – with or without). Analysis I was performed

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Table 1a. Least square means of mineral composition of strip loins (m. *longissimus lumborum*) from cattle fed different dietary regimes.

	Supplemented with E					Non-supplemented with E					
	0	20 L	20 H	40 L	40 H	0	20 L	20 H	40 L	40 H	SEM
Ca[1]	0.011	0.016	0.019	0.015	0.018	0.019	0.011	0.020	0.015	0.020	0.001
P[1]	0.195	0.192	0.203	0.199	0.206	0.204	0.198	0.205	0.195	0.208	0.003
K[1]	0.338	0.332	0.333	0.348	0.340	0.324	0.348	0.329	0.338	0.349	0.007
Mg[1]	0.023	0.021	0.021	0.023	0.021	0.022	0.024	0.021	0.024	0.025	0.001
Zn[2]	34.70	36.32	35.53	35.14	36.41	35.29	34.24	34.60	33.44	35.43	1.25
Fe[2]	14.13	14.33	18.00	15.00	18.60	17.50	16.10	17.13	16.40	17.75	0.85
Mn[2]	1.625	2.111	2.000	1.250	2.900	2.700	1.000	2.875	1.200	2.625	0.60
Cu[2]	0.738	0.811	1.374	0.738	0.620	0.830	0.840	1.288	0.640	0.600	0.25
S[1]	0.168	0.200	0.204	0.185	0.191	0.186	0.158	0.205	0.171	0.211	0.01
Na[1]	0.049	0.050	0.051	0.051	0.051	0.051	0.051	0.050	0.051	0.051	0.001

[1]% on dry matter basis.
[2]ppm on dry matter basis.
WDG = wet distillers grains 0, 20, and 40% on DM basis.
Distillers soluble (DS) levels: L = 100:0 of WDG:DG, H = 70:30 of WDG:DS on DM basis.
E = vitamin E.

Table 1b. *P*-values of mineral levels of strip loins (m. *longissimus lumborum*) from analysis I and II.

	Analysis I[1]			Analysis II[2]						
	E	WDG	E ×WDG	E	WDG	DS	E ×WDG	E × DS	DS ×WDG	E ×DS ×WDG
Ca	0.37	0.36	0.0004	0.70	0.50	<.0001	0.15	0.05	0.25	0.33
P	0.19	0.43	0.16	0.59	0.37	0.0002	0.32	0.91	0.87	0.34
K	0.69	0.26	0.11	0.58	0.10	0.43	0.53	0.91	0.26	0.05
Mg	0.30	0.80	0.54	0.04	0.22	0.43	0.55	0.95	0.58	0.20
Zn	0.29	0.70	0.49	0.10	0.93	0.42	0.92	0.59	0.29	0.90
Fe	0.0019	0.75	0.45	0.53	0.34	<.0001	0.88	0.04	0.91	0.87
Mn	0.94	0.16	0.09	0.74	0.99	0.01	0.96	0.30	0.44	0.19
Cu	0.95	0.69	0.84	0.86	0.04	0.31	0.91	0.99	0.16	0.84
S	0.26	0.99	0.09	0.33	0.80	0.01	0.19	0.04	0.89	0.82
Na	0.31	0.59	0.59	0.97	0.46	0.97	0.97	0.62	0.97	0.42

[1]Analysis of treatments containing low levels of DS with 0, 20, or 40% WDG with or without E.
[2]Analysis of treatments containing low and high levels of DS with 20 or 40% WDG with or without E.

in order to find the effect of feeding WDG, vitamin E supplementation or their combinations on each parameter in the absence of DS in the diet. In analysis II, diets containing 20 or 40% WDG with low or high levels of DS and with or without E were analyzed as a 2 × 2 × 2 factorial design (2 levels of WGD, 20 and 40%; two levels of E, with or without; and two levels of DS, low or high). Analysis II was carried out to find the effects of feeding WDG, DS, E or their combinations on each parameter. Least square means were calculated using LSMEANS of SAS. The *P*-values of E, WDG, DS, and their interactions were separately tabulated to determine their effect on each parameter analyzed. Significant effects were tested at $P < 0.05$. Mean separation was performed using DIFF and LINES options of SAS at $P < 0.05$.

Results

Mineral composition (Ca, P, K, Mg, Zn, Fe, Mn, Cu, S, and Na) of strip loins obtained from animals fed different dietary treatments are shown in Table 1a. There were no significant effects of feeding WDG or E on mineral levels of strip loins, except that vitamin E-supplemented diets in analysis I resulted in less Fe in strips than non-E supplemented diets among diets without DS (Table 1b). In analysis II, Ca, P, Fe, Mn, and S levels significantly increased in strip loins from animals fed DS compared to cattle fed no DS diets. Although there was a significant interaction effect of E and DS on Fe and S levels in strip loins, diets containing DS always showed higher levels of Fe and S than diets without DS (Table 1a). Feeding DS increased Fe levels in strip loin steaks by 3-4 ppm when E was added to the diet; without supplemented E, the increase was about 1 ppm. Results of this study also showed that feeding DS increased S and Fe levels in strip loins; therefore, DS may cause off-flavor production in beef (Senaratne et al., *2010 Nebraska Beef Report*, pp. 101-103).

Mineral levels and *P*-values of tenderloins are shown in Tables 2a and 2b, respectively. Similar effect of E, WDG, and DS as shown in strip loins were not observed in tenderloins. Tenderloins from cattle fed diets without DS supplemented with E contained lower levels of P and Mg than tenderloins from cattle fed non-E supplemented diets ($P < 0.05$). Neither WDG nor E significantly affected Ca, K, Zn, Fe, Mn, Cu, S, and Na levels

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Table 2a. Least square means of mineral composition of tenderloins (m. *psoas major*) from cattle fed different dietary regimes.

	Supplemented with E					Non-supplemented with E					
	0	20 L	20 H	40 L	40 H	0	20 L	20 H	40 L	40 H	SEM
Ca[1]	0.020	0.020	0.019	0.019	0.017	0.016	0.017	0.018	0.019	0.014	0.002
P[1]	0.205	0.203	0.201	0.210	0.206	0.198	0.204	0.200	0.199	0.199	0.003
K[1]	0.339	0.333	0.326	0.343	0.338	0.329	0.338	0.329	0.331	0.334	0.004
Mg[1]	0.030	0.029	0.025	0.030	0.024	0.026	0.029	0.024	0.028	0.026	0.001
Zn[2]	32.29	34.09	35.66	34.29	35.46	35.56	34.41	34.91	33.26	34.30	1.08
Fe[2]	20.88	20.56	21.13	21.63	20.50	21.10	19.90	21.13	21.00	21.75	0.66
Mn[2]	1.625	0.667	1.500	1.125	1.900	1.700	1.800	0.500	0.700	0.625	0.47
Cu[2]	3.163	1.656	1.225	1.488	1.180	1.510	2.020	1.225	1.770	1.550	0.54
S[1]	0.208	0.234	0.229	0.224	0.240	0.222	0.223	0.215	0.219	0.223	0.01
Na[1]	0.050	0.050	0.048	0.050	0.047	0.047	0.050	0.049	0.050	0.048	0.001

[1]% on dry matter basis.
[2]ppm on dry matter basis.
WDG = wet distillers grains 0, 20, and 40% on DM basis.
Distillers soluble (DS) levels: L = 100:0 of WDG:DG, H = 70:30 of WDG:DS on DM basis.
E = vitamin E.

Table 2b. *P*-values of mineral levels of tenderloins (m. *psoas major*) from analysis I and II.

	Analysis I[1]			Analysis II[2]						
	E	WDG	E ×WDG	E	WDG	DS	E ×WDG	E × DS	DS ×WDG	E ×DS ×WDG
Ca	0.10	0.87	0.42	0.09	0.26	0.07	0.77	0.68	0.14	0.22
P	0.04	0.65	0.21	0.02	0.50	0.18	0.02	0.81	0.81	0.46
K	0.13	0.81	0.14	0.46	0.11	0.13	0.05	0.66	0.22	0.42
Mg	0.04	0.62	0.20	0.83	0.69	0.0001	0.74	0.48	0.74	0.17
Zn	0.30	0.89	0.10	0.44	0.60	0.20	0.60	0.72	0.97	0.78
Fe	0.51	0.23	0.75	0.99	0.24	0.44	0.48	0.17	0.24	0.51
Mn	0.46	0.23	0.19	0.22	0.93	0.85	0.15	0.02	0.36	0.31
Cu	0.49	0.48	0.17	0.42	0.91	0.17	0.82	0.83	0.58	0.72
S	0.95	0.41	0.44	0.18	0.91	0.86	0.93	0.67	0.34	0.77
Na	0.21	0.21	0.21	0.61	0.61	0.01	0.83	0.61	0.61	0.83

[1]Analysis of treatments containing low levels of DS with 0, 20, or 40% WDG with or without E.
[2]Analysis of treatments containing low and high levels of DS with 20 or 40% WDG with or without E.

in tenderloins from animals fed non-DS diets. Feeding DS significantly reduced the concentration of Mg and Na in tenderloins compared to feeding non-DS diets, regardless of feeding WDG or E together. Feeding DS diets had less dramatic effect on mineral contents of tenderloins than on mineral contents of strip loins.

Intuitively, differences among muscles could be expected for mineral contents as influenced by diet, likely caused by vascularity, muscle function, and fiber type composition. However, the biological reason is unclear for differences in mineral content observed here.

As a whole, the presence or absence of vitamin E or WDG had few effects on mineral composition of both strip loins and tenderloins. Feeding DS significantly increased the Ca, Fe, P, Mn, and S contents of strip loins over non-DS diets.

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