Effect of Cooking Method, Distiller’s Grains, and Vitamin E Supplementation on the Vitamin Content of Value Cuts from Beef Steers FedWet Distiller’s Grains and Solubles and Supplemental Vitamin E

by Mellova Amir

C: Food Chemistry

Effect of Cooking Method, Distiller's Grains, and Vitamin E Supplementation on the Vitamin Content of Value Cuts from Beef Steers Fed Wet Distiller's Grains and Solubles and Supplemental Vitamin E

Y.N. Kim, D.W. Giraud, M.A. Masrizal, F.L. Hamouz, K. Watanabe, M.I. Schnepf, A.S. de Mello, Jr., G.E. Erickson, C.R. Calkins, and J.A. Driskell

ABSTRACT: Vitamin E, thiamin, riboflavin, niacin, vitamin B_6, and vitamin B_{12} concentrations of flat iron steaks and petite tenders from steers fed finishing rations containing 0% and 40% corn wet distiller's grains and solubles (WDGS) with and without supplemental vitamin E were determined. Feeding treatment groups were: 0% WDGS with basal vitamin E, 0% WDGS with supplemental vitamin E (500 IU daily), 40% WDGS with basal vitamin E, and 40% WDGS and supplemental vitamin E. Cattle can be fed 40% WDGS diets more economically than corn diets. The incorporation of 40% WDGS, with and without vitamin E, was hypothesized to have little effect on the vitamin concentrations of these value meat cuts. Flat iron steaks and petite tenders were broiled and/or grilled to 70 °C internal temperature. Mean cooking yields ranged from 68.7% to 78.2%. The majority of the vitamin concentrations of broiled and of grilled meat were significantly different ($P < 0.05$) from that of raw meat. Vitamin E concentrations of raw and cooked meat from steers that received supplemental vitamin E were significantly higher ($P < 0.05$) than those fed basal vitamin E. Significant differences in thiamin, riboflavin, vitamin B_6, and vitamin B_{12} concentrations in raw flat iron steaks and in vitamin B_6 in raw petite tenders were observed by WDGS. Thiamin, vitamin B_6, and vitamin B_{12} concentrations of broiled flat iron steaks were significantly different ($P < 0.05$) than grilled. A few differences in vitamin concentrations of the flat iron steaks and petite tenders were observed by WDGS, vitamin E supplementation, and cooking treatments, but most of the vitamin concentrations were statistically similar.

Keywords: broiled beef, grilled beef, vitamin E supplementation, vitamins, wet distiller's grains and solubles

Introduction

Today many beef producers feed their animals rations containing wet distiller's grains and solubles (WDGS), a by-product of ethanol production from grains, especially corn. These by-products offer cattle producers an opportunity to reduce feed costs without sacrificing performance (Klopfenstein 2001). WDGS are high in polyunsaturated fatty acid (PUFA) concentrations (de Mello and others 2008). The dietary vitamin E requirements of animals including beef cattle are dependent on the quantities of PUFAs, other antioxidants, sulfur-containing amino acids, and selenium (McDowell 1989; NRCNAS 2000); thus, beef steers have been fed supplemental vitamin E (Arnold and others 1992; Liu and others 1995; Zerby and others 1999). Vitamin E is a potent fat-soluble antioxidant (Tappel 1972; McCay and King 1980; IMNAS 2000). The feeding of vitamin E to beef cattle has been reported to minimize the rancidity problem (Arnold and others 1992, 1993; Liu and others 1995; Sanders and others 1997). Alpha-tocopherol is the only form of the tocopherols and tocotrienols that has vitamin E activity (IMNAS 2000).

MS 20090796 Submitted 8/18/2009, Accepted 10/23/2009. *Authors Kim, Giraud, Masrizal, Hamouz, Watanabe, Schnepf, and Driskell are with the Dept. of Nutrition and Health Sciences and authors de Mello, Erickson, and Calkins are with the Dept. of Animal Science, Univ. of Nebraska, Lincoln, NE 68583-0806, U.S.A. Direct inquiries to author Driskell (E-mail: jdriskell@unl.edu).*

The beef value cuts flat iron steak (musculus infraspinatus) and petite tender (teres major) are meat cuts that have recently been fabricated (NAMPA 2006). These 2 meat cuts are actually newer cuts that incorporate ways of butchering less tender meat such that the meat cuts are more tender. Information is not available as to whether feeding beef steers WDGS and/or supplemental vitamin E influences the vitamin content of these cuts. The cooking of meat is essential with regard to food safety issues (USDA, Food Safety and Inspection Service 2003). Consumers and food service establishments are serving flat iron steaks and petite tenders, and consumers want information on the vitamin content of these cooked value cuts. Broiling and grilling are common methods utilized for the cooking of beef steaks.

In that feeding beef steers WDGS reduces feed costs and does not sacrifice animal performance, information is needed as to whether this practice influences the vitamin content of meat from these steers as a food source for humans. Also, does the vitamin E supplementation of the steers influence the vitamin content of meat from these steers as consumed by humans? The objectives of this study were to determine the selected vitamin concentrations of raw, broiled, and grilled flat iron steaks and petite tenders from beef steers fed 0% and 40% WDGS with basal and supplemental quantities of vitamin E. The steaks were cooked to medium doneness. The vitamins that were quantified in these meat cuts were: vitamin E (α-tocopherol), thiamin, riboflavin, niacin, vitamin B_6, and

doi: 10.1111/j.1750-3841.2009.01471.x

THE Society for Food Science & Technology
Journal of Food Science
A Publication of the Institute of Food Technologists

vitamin B_{12}. These are vitamins found in red meats that some population groups of Americans reportedly consume in lower amounts than recommended (USDA, ARS 2009). The nutrient contributions of these vitamins determined to be present in these 2 value meat cuts to the dietary needs of humans were estimated as percentages of the Daily Values (USFDA 2008). The Daily Values are nutrient recommendations established by the U.S. Food and Drug Administration (FDA) for nutrition labeling.

Materials and Methods

Sample description

Cross-bred beef steers were fed finishing rations containing 0% and 40% WDGS with and without supplemental vitamin E (500 IU/steer top-dressed daily) for 140 d at the Univ. of Nebraska-Lincoln Agricultural Research and Development Center research feedlot (near Mead, Nebr., U.S.A.). The diets met the nutrient requirements of beef cattle (NRCNAS 2000). The WDGS from corn contained 32.7% dry matter (DM). On a DM basis, WDGS contained 32.6% crude protein, 11.5% crude fat, and 42.4% fiber. The 0% WDGS diet fed to some of the steers contained 82.5% corn (1 : 1 ratio of dry-rolled and high moisture corn on a DM basis) and 5% molasses, whereas the 40% WDGS diets contained 40% WDGS and 47.5% corn. Steers fed the basal level of vitamin E received 23.6 IU α-tocopherol/kg in the 0% WDGS diet and 45.3 IU/kg in the 40% WDGS diet. All animal care procedures were conducted in accordance with the Univ. of Nebraska-Lincoln Inst. for Animal Care and Use Committee.

Six steers from each of the following 4 feeding groups were available for this study: 1) 0% WDGS and basal vitamin E, 0% WDGS and supplemental vitamin E, 40% WDGS and basal vitamin E, and 40% WDGS and supplemental vitamin E. Initial body weights, hot carcass weights, and final body weights of the steers were recorded. The steers were slaughtered on d 140 at a commercial abattoir (Greater Omaha Pack, Omaha, Nebr., U.S.A.); the steers were approximately 17 mo of age. Shoulder clods were removed, vacuum-packed, kept at 5 °C, and transported to the Univ.'s Loeffel Meat Lab. and aged for 7 d at 1 °C. Flat iron steaks (North American Meat Processors Assoc. #114D) were fabricated from both shoulder clods. Petite tenders (North American Meat Processors Assoc. #114F) were filleted from both shoulder clods, and the connective tissue that runs through the middle was removed. The meat cuts, all graded as choice, were trimmed of all visible fat. Both meat cuts were then stored at −80 °C.

Cooking of steaks

The flat iron steaks and petite tenders from each steer were thawed to 5 °C. Prior to cooking, representative samples of flat irons and petite tenders from each of the 24 steers were homogenized with liquid nitrogen and stored at −80 °C for future vitamin analyses. A flat iron steak from each of the 24 steers was cooked to medium doneness (70 °C internal temperature) by broiling as well as by grilling, while petite tenders, one from each of the 24 steers, were cooked by broiling as sufficient sample was not available for cooking by 2 methods. The internal temperatures of the steaks were measured during cooking using thermocouples (Polder original cooking timer and thermometer, Oxford, Conn., U.S.A.) that were centrally placed. For broiling, samples were turned at 34 °C and removed from the oven at 68 °C (Maytag Electrical Schematic FP860-910A, Benton Harbor, Mich., U.S.A.); samples reached 70 °C in 5 min. For grilling, samples were cooked on an electric grill (Presto Series 0702 griddle, Eau Claire, Wis., U.S.A.), turned at 38 °C, removed from the grill at 68 °C, and the samples reached 70 °C in 5 min. Samples were weighed immediately before and after cooking to determine cooking yield. Cooking time was also measured. Immediately after cooking, representative cooked samples were homogenized with liquid nitrogen, and aliquots were frozen at −80 °C for future vitamin analyses.

Vitamin analyses

Meat aliquots, sufficiently large enough to ensure uniform lipid content, were thawed to 5 °C prior to each of the vitamin analyses. Selected vitamins found in flat iron steaks and petite tenders were quantified; the moisture and total lipid concentrations were also determined (AOAC 2006). The α-tocopherol content of the meat samples as well as the diet top-dressings containing or not containing the supplemental vitamin E were assayed using high-performance liquid chromatography (HPLC) techniques (Chun and others 2006; Kim and others 2007). Thiamin, riboflavin, and niacin were determined using the HPLC procedure of Dawson and others (1988). The vitamin B_6 and vitamin B_{12} concentrations of the samples were determined by microbiological assays (Sauberlich 1967; AOAC 2006) using *Saccharomyces uvarum* (ATCC 9080) and *Lactobacillus leichmannii* (ATCC 7830), respectively. The concentrations of each of these 6 vitamins, moisture, and total lipids were determined for raw, broiled, and grilled flat iron steaks and raw and broiled petite tenders from each of the 24 steers (total of 120 samples), all performed in duplicate. These methods or similar methods had been used previously in our laboratory for determining the selected vitamin content of several cuts from bison (*Bison bison*) (Driskell and others 1997, 2000).

The identities of the vitamins were confirmed by standard addition (spiking) of beef samples with the appropriate vitamin prior to extraction; vitamin recoveries were > 90%. The extraction method and the HPLC or microbiological analytical methods were also validated using Standard Reference Material 2383 (baby food composite, National Inst. of Standards and Technology, Gaithersburg, Md., U.S.A.). The coefficients of variance for all vitamins were < 10%. All content values are expressed on a wet weight (w/w) basis.

Statistical analyses

All data were analyzed using the mixed model analysis of variance (ANOVA) procedure (Dowdy and others 2004) using SAS software (Statistical Analysis Software version 9.1, 2002–2003, Cary, N.C., U.S.A.). The model was WDGS treatment, vitamin E supplementation, and WDGS∗vitamin E supplementation interaction. Cooking treatment was included in the model when appropriate. The vitamin contents of the 2 meat cuts were also compared using the mixed model ANOVA implemented in PROC MIXED (Statistical Analysis Software version 9.1); the individual cut was the experimental unit, and animal was treated as a random block effect. The data are given as LS mean ± SE. Differences were considered significant at $P < 0.05$.

Results and Discussion

The initial body weights of the steers prior to finishing treatment were a mean of 385.4 ± 1.7 kg. Carcass weights of the steers at slaughter ranged from means of 372.3 to 409.5 (SE = 6) and final body weights ranged from 591 to 650.3 (SE = 9.6) by treatment group. Initial body weights, carcass weights, and final body weights of the steers by treatment group were similar. The steers received either 23.6 or 45.3 IU α-tocopherol/kg from the finishing diets containing basal levels of the vitamin. The vitamin E requirement for growing beef cattle has been reported to be 15 to 60 IU/kg feed (McDowell 1989). Steers in the present study that received supplemental vitamin E were fed an additional 500 IU α-tocopherol daily. Steers in the current study consumed around 11 to 12 kg diet/d. Quantitative analyses indicated that the diet top-dressings contained the appropriate quantities of α-tocopherol.

Cooking yield and time

Cooking yields and times of broiled and grilled flat iron steaks and broiled petite tenders are given in Table 1. No significant differences were observed in cooking yields or times in each of the cuts by animal treatment. The cooking yields for broiled flat iron steaks were significantly higher ($P < 0.0001$) than for grilled (mean of 72.8% compared with 68.7%). Cooking times for broiled flat iron steaks were significantly greater ($P < 0.0001$) than for grilled (mean of 23.9 compared with 17.7 min). The mean cooking yield was 78.2% for broiled petite tenders and the mean cooking time was 25.3 min. The cooking yields in the current study were in line with those reported by Yang and others (1994) for stir-fried, microwaved, and broiled beef strips from round steaks and by Gerber and others (2009) for grilled beef ribeye.

Table 1 – Cooking yields and times of raw, broiled, and grilled flat iron steaks and raw and petite tenders by animal treatment.[a]

% WDGS[b]	No vitamin E supplementation Broiled	No vitamin E supplementation Grilled	Vitamin E supplementation Broiled	Vitamin E supplementation Grilled	SE[c]
Cooking yields (%)					
Flat iron steaks					
0	74.3	67.9	71.1	68.6	1.5
40	73.9	69.8	72.0	68.6	1.5
Petite tenders					
0	79.1	–	76.2	–	1.5
40	78.5	–	78.9	–	1.5
Cooking times (min)					
Flat iron steaks					
0	23.3	16.5	25.5	19.2	1.67
40	23.1	16.5	23.8	18.7	1.67
Petite tenders					
0	25.0	–	26.1	–	0.8
40	24.9	–	25.1	–	0.8

[a]Values are least squares means ± SE. Significance was determined by the proc mixed procedure. Number of steers/group = 6.
[b]Wet distiller's grains and solubles.
[c]SE of cooked samples.

Moisture and total lipid content

The moisture and total lipid concentrations of the flat iron steaks as well as the petite tenders were not influenced by WDGS treatment, vitamin E supplementation, or cooking method. The mean moisture and total lipid concentrations (g/100 g w/w), respectively, were as follows: flat iron steaks – raw, 69.5 and 13.2 g; broiled, 60.5 and 14.2 g; grilled 60 and 13 g; petite tenders – raw, 73.2 and 8.6 g; broiled, 65.2 and 7.7 g. The quantities of water and of total lipids did not appear to influence the concentrations of the vitamins in the 2 meat cuts in the current study.

Nutrient content

The selected vitamin concentrations of raw flat iron steaks by animal treatment are given in Table 2. All 6 vitamin concentrations were significantly different ($P < 0.05$) in raw flat iron steaks than in those that were broiled or grilled with concentrations of vitamin E (α-tocopherol) and vitamin B_{12} being higher in the cooked while concentrations of thiamin, riboflavin, niacin, and vitamin B_6 were lower. The thiamin and vitamin B_6 concentrations of broiled flat iron steaks were significantly higher ($P = 0.0001$ and $P = 0.0057$, respectively) than that which was grilled; however, the opposite was true for vitamin B_{12} ($P < 0.0001$). As expected, the α-tocopherol concentrations were significantly higher ($P < 0.0001$) in raw and

Table 2 – Selected vitamin concentrations of raw, broiled, and grilled flat iron steaks by animal treatment.[a]

% WDGS[b]	No vitamin E supplementation Raw	No vitamin E supplementation Broiled	No vitamin E supplementation Grilled	Vitamin E supplementation Raw	Vitamin E supplementation Broiled	Vitamin E supplementation Grilled	SE[c]
α-tocopherol (mg/100 g)							
0	0.480	0.570^{d}	0.578^{d}	0.639^{e}	0.800^{de}	0.832^{de}	0.030/0.057
40	0.527	0.632^{d}	0.663^{d}	0.817^{ef}	0.946^{de}	0.863^{de}	0.030/0.057
Thiamin (mg/100 g)							
0	0.064	0.054^{dh}	0.048^{d}	0.048	0.046^{dh}	0.041^{d}	0.003/0.003
40	0.056^{g}	0.05^{dh}	0.045^{d}	0.068^{g}	0.061^{dh}	0.053^{d}	0.003/0.003
Riboflavin (mg/100 g)							
0	0.250	0.222^{d}	0.237^{d}	0.280	0.241^{d}	0.255^{d}	0.017/0.024
40	0.313^{h}	0.278^{d}	0.254^{d}	0.318^{i}	0.301^{d}	0.263^{d}	0.017/0.024
Niacin (mg/100 g)							
0	3.737	2.868^{d}	2.981^{d}	3.326	2.859^{d}	2.515^{d}	0.357/0.442
40	3.414	2.970^{d}	2.865^{d}	2.722	2.066^{d}	1.964^{d}	0.357/0.442
Vitamin B_6 (mg/100 g)							
0	0.240	0.219^{dj}	0.213^{d}	0.243	0.216^{dj}	0.210^{d}	0.009/0.014
40	0.245	0.209^{dj}	0.203^{d}	0.247	0.206^{dj}	0.201^{d}	0.009/0.014
Vitamin B_{12} (μg/100 g)							
0	5.780^{k}	6.392^{dk}	6.497^{dkl}	5.622^{k}	6.235^{dk}	6.832^{dkl}	0.449/0.425
40	4.109	5.440^{d}	5.659^{dk}	4.072	4.843^{d}	5.640^{dk}	0.449/0.425

[a]Values are least squares means ± SE. Significance was determined by the proc mixed procedure. Number of steers/group = 6.
[b]Wet distiller's grains and solubles.
[c]SE of raw/cooked samples.
[d]Vitamin concentrations of broiled and of grilled meat were significantly different ($P < 0.05$) than that of raw meat.
[e]α-Tocopherol concentrations of raw, broiled, and grilled meat from vitamin E supplemented steers were significantly higher ($P < 0.0001$) than raw, broiled, and grilled meat, respectively, from steers not supplemented with vitamin E.
[f]α-Tocopherol concentrations of raw meat from vitamin E supplemented steers fed 40% WDGS were significantly higher ($P < 0.0005$) than from those fed 0%.
[g]Thiamin concentrations of raw meat from animals fed 40% WDGS were significantly higher ($P = 0.0467$) than that from those fed 0% WDGS.
[h]Thiamin concentrations of broiled meat were significantly higher ($P = 0.0001$) than that of grilled meat.
[i]Riboflavin concentrations of raw meat from steers fed 40% WDGS were significantly higher ($P = 0.0057$) than from those fed 0%.
[j]Vitamin B_6 concentrations of broiled meat were significantly higher ($P < 0.0001$) than that of grilled meat.
[k]Vitamin B_{12} concentrations in raw ($P < 0.0001$), broiled, and grilled ($P = 0.0162$) meat from steers fed 0% WDGS were significantly higher than for raw, broiled, and grilled meat, respectively, from those fed 40%.
[l]Vitamin B_{12} concentrations in grilled meat were significantly higher ($P < 0.0001$) than that of broiled.

cooked flat iron steaks from steers fed supplements of the vitamin than in those from unsupplemented steers. The thiamin and riboflavin concentrations of raw meat from steers fed 40% WDGS were significantly higher ($P < 0.05$) than those from steers fed 0% WDGS. The vitamin B_{12} concentrations in raw, broiled, and grilled meat from steers fed 0% WDGS were significantly higher ($P < 0.05$) than for raw, broiled, and grilled meat from steers fed 40% WDGS. No significant vitamin E∗WDGS interactions were observed for any of the vitamins.

The selected vitamin concentrations of raw and broiled petite tenders by animal treatment are given in Table 3. Thiamin, riboflavin, and niacin concentrations were significantly higher ($P < 0.05$) in raw than broiled petite tenders. As expected, the α-tocopherol concentrations of raw and broiled petite tenders from steers that were vitamin E-supplemented were significantly higher ($P < 0.0005$ and $P < 0.0233$, respectively) than in those from unsupplemented animals. The vitamin B_6 concentrations of raw and broiled meat from steers fed 40% WDGS were significantly higher ($P < 0.05$) than those from steers fed 0% WDGS. No significant supplemental vitamin E∗WDGS interactions were observed for any of the vitamins measured in petite tenders.

The vitamin concentrations of the raw flat iron steaks and petite tenders in the current study were generally comparable to the values given for NDB No. 23041 (beef, chuck, shoulder clod, top blade, steak, separable lean and fat, trimmed to 0” fat, choice, raw for flat iron) and NDB No. 23034 (beef, chuck, shoulder clod, shoulder tender, medallion, separable lean and fat, trimmed to 0” fat, choice, raw for petite tender), for which there were 1 or 2 data points for each cut, in USDA's National Nutrient Database for Standard Reference (2008). The vitamin B_6 concentrations of the 2 cuts in the current study were closer to the 0.26 mg/100 g w/w reported for lean tissues of the foreloin of 54 bulls (Kirchgessner and others 1995), for ground beef (Gregory and others 1981), for 70% lean beef roast (Dong and others 1980), and for beef sirloin, fillet, roast beef, topside, and thick flank (Lombardi-Boccia and others 2005). The vitamin concentrations of the 2 cuts in the current study were in line with those reported for various beef cuts for thiamin (Dong and others 1980; Yang and others 1994; Lombardi-Boccia and others 2005), riboflavin (Dong and others 1980; Lombardi-Boccia and others 2005), and niacin (Lombardi-Boccia and others 2005).

The vitamin concentrations of grilled flat iron steaks and petite tenders in the current study were generally comparable with values given for NDB No. 23042 (beef, chuck, shoulder clod, top blade, steak, separable lean and fat, trimmed to 0” fat, choice, grilled for flat iron) and NDB No. 23035 (beef, chuck, shoulder clod, shoulder tender, medallion, separable lean and fat, trimmed to 0” fat, choice, cooked, grilled for petite tender) for which there were 1 or 2 data points for each cut, in USDA's Natl. Nutrient Database for Standard Reference (2008), though vitamin B_6 concentrations were somewhat lower. The vitamin B_6 concentrations of the 2 cuts in the current study were closer to those reported by Gregory and others (1981) for cooked ground beef. The various B vitamin concentrations of the grilled and broiled flat iron steaks and the broiled petite tenders in the current study were generally comparable to or somewhat higher than those reported for various beef cuts by Yang and others (1994), Lombardi-Boccia and others (2005), and Gerber and others (2009). Vitamin cooking retention values for the B vitamins in the current study were generally similar to those reported by USDA (2003). The vitamin E retention values observed in this study were slightly higher than values reported by Yuan and others (1999) for broiled and grilled bison patties.

Vitamin B_{12} is not an essential nutrient for beef cattle as their ruminal microorganisms can synthesize vitamin B_{12} from dietary cobalt (NRCNAS 2000). Feeding high-concentrate diets may (Walker and Elliot 1972; Halpin and others 1984) or may not (MacPhearson and Chalmers 1984) decrease ruminal vitamin B_{12} synthesis. The feeding of higher quantities of WDGS has been reported to alter ruminal pH (Corrigan and others 2009; Vander Pol and others 2009). Perhaps the decreased ruminal pH may have influenced the ruminal synthesis of vitamin B_{12} in steers fed 40% WDGS in the present study, thus decreasing the vitamin B_{12} concentrations particularly in the flat iron steaks from these animals.

Evidence exists that thiamin can be synthesized by the ruminal microflora; however, the synthesis is subject to dietary factors including the dietary carbohydrate and nitrogen supply (McDowell 1989; NRCNAS 2000). The consumption of higher quantities of WDGS influencing the ruminal pH (Corrigan and others 2009; Vander Pol and others 2009) may have influenced the synthesis of thiamin, and thus the thiamin concentrations in the 2 beef cuts in the current study.

Riboflavin, niacin, and vitamin B_6 are not essential nutrients for adult ruminants as ruminal microorganisms synthesize these B vitamins in adequate amounts; however, deficiencies of these vitamins can occur in young ruminants (McDowell 1989; NRCNAS 2000). The consumption of the higher quantities of WDGS may have also influenced the synthesis of these 3 B vitamins.

It was not surprising that vitamin E supplementation significantly increased the vitamin E concentrations of the 2 cuts in the current study in that supplementation with the vitamin has been reported to increase the α-tocopherol concentrations in beef muscles (Hidiroglou and others 1988; Faustman and others 1989; Arnold and others 1993; Granit and others 2001; Lahučký and others 2002). Alpha-tocopherol accumulation also is muscle-dependent (Arnold and others 1992, 1993; Lahučký and

Table 3 – Selected vitamin content of raw and broiled petite tenders by animal treatment.[a]

	No vitamin E supplementation		Vitamin E supplementation		
% WDGS[b]	Raw	Broiled	Raw	Broiled	SE[c]
α-tocopherol (mg/100 g)					
0	0.503	0.551	0.787[d]	0.761[d]	0.052/0.063
40	0.597	0.647	0.742[d]	0.747[d]	0.052/0.063
Thiamin (mg/100 g)					
0	0.067[e]	0.060	0.055[e]	0.054	0.005/0.005
40	0.069[e]	0.056	0.070[e]	0.058	0.005/0.005
Riboflavin (mg/100 g)					
0	0.269[e]	0.231	0.255[e]	0.197	0.027/0.025
40	0.263[e]	0.224	0.250[e]	0.204	0.027/0.025
Niacin (mg/100 g)					
0	3.049[e]	2.569	2.942[e]	2.640	0.203/0.265
40	3.187[e]	2.624	3.212[e]	2.594	0.203/0.265
Vitamin B_6 (mg/100 g)					
0	0.339	0.302	0.369	0.361	0.024/0.021
40	0.426[f]	0.384[f]	0.396[f]	0.371[f]	0.024/0.021
Vitamin B_{12} (μg/100 g)					
0	3.308	3.419	3.140	3.306	0.360/0.319
40	3.351	3.351	3.812	3.718	0.360/0.319

[a]Values are least squares means ± SE. Significance was determined by the proc mixed procedure. Number of steers/group = 6.
[b]Wet distiller's grains and solubles.
[c]SE of raw/cooked samples.
[d]α-Tocopherol concentrations of raw ($P < 0.0005$) and broiled ($P = 0.0223$) meat from vitamin E supplemented steers were significantly higher than those from nonsupplemented steers.
[e]Thiamin, riboflavin, and niacin concentrations were significantly higher ($P < 0.05$) in raw than in broiled samples.
[f]Vitamin B_6 concentrations of raw ($P = 0.0256$) and broiled ($P = 0.0394$) meat from steers fed 40% WDGS were significantly higher than those from steers fed 0% WDGS.

others 2002). Vitamin E supplementation of beef cattle results in higher α-tocopherol concentrations in all meat cuts (Zerby and others 1999). Vitamin E supplementation of cattle has been reported to result in steaks with more desirable overall appearance, less lipid oxidation (Sanders and others 1997), and less oxidative susceptibility (O'Grady and others 2001; Lahučký and others 2002) than observed in steaks from unsupplemented cattle. In the current study, vitamin E supplementation during finishing resulted in higher ($P = 0.0675$) α-tocopherol concentrations in flat iron steaks but not petite tenders in steers fed 40% WDGS diets as compared to those fed 0% WDGS.

The stability of the vitamins to food processing including cookery methods has been reviewed by Kim and others (2009). During processing vitamin E, a fat-soluble vitamin, is lost rather rapidly. Loss is accelerated by oxygen, light, heat, and various metals as well as by the presence of free radicals in the fat. All of the B-vitamins are water-soluble and unless humans consume the drip in the case of meats, some of the B-vitamins as well as smaller quantities of the vitamin E contents are lost. Thiamin is the most heat-labile of the B-vitamins, with its decomposition dependent on pH and exposure time to heat. Riboflavin is stable to heat, acidic conditions, and oxidation if ultraviolet and visible light are excluded. Niacin is not greatly influenced by thermal processing, light, oxygen, and pH. Vitamin B_6 is unstable to ultraviolet and visible light as well as alkaline pH. Vitamin B_{12} is generally stable to thermal processing but not strong acid or alkaline conditions, intense visible light, and oxidizing agents. The vitamin concentrations given in Table 2 and 3 are given per 100 g w/w with the drip having been removed by blotting. The B-vitamin content of the cooked meats in the present study generally contained lower amounts of these B-vitamins, especially once yield is taken into account. The true retention values (Murphy and others 1975) for vitamin E and vitamin B_{12} were around 83% to 84%, while those for thiamin, riboflavin, niacin, and vitamin B_6 were around 60% to 63%. The only significant difference observed by cooking method was for vitamin B_{12} in which the concentration (μg/100 g w/w) was higher in grilled meat than broiled. These values are generally similar to those given for the B-vitamins in beef, broiled cut (values not given for vitamin E) in USDA's Table of Nutrient Retention Factors (2007).

In the current study, the vitamin E, thiamin, and niacin concentrations of raw and broiled flat iron steaks and petite tenders were similar as was the riboflavin content of the raw cuts. Significant differences ($P < 0.0001$) between the vitamin B_6 and vitamin B_{12} concentrations were observed between flat iron steaks and petite tenders in both their raw states and those broiled; however, the retention values for vitamin B_6 and vitamin B_{12} for the 2 cuts were similar. A significant difference ($P = 0.0149$) in riboflavin concentrations was observed between broiled flat iron steaks and petite tenders; however, the retention values for riboflavin for the 2 cuts were similar. Much individual variation was observed in these

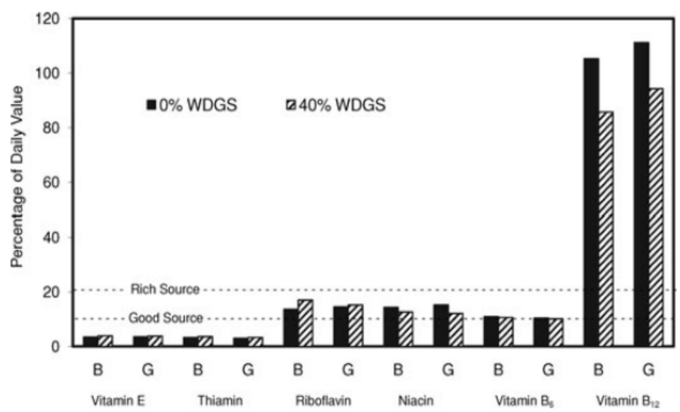

Figure 1–Percentage of vitamin Daily Values available through consumption of 100 g w/w of broiled and grilled flat iron steaks. B = broiled; G = grilled. WDGS = wet distiller's grains and solubles. These flat iron steaks had been graded as choice, separable lean only, and trimmed to 0" fat. The vitamin E (α-tocopherol) concentrations of cooked steaks from steers supplemented with vitamin E were significantly higher than for steaks from nonsupplemented steers (see Table 2).

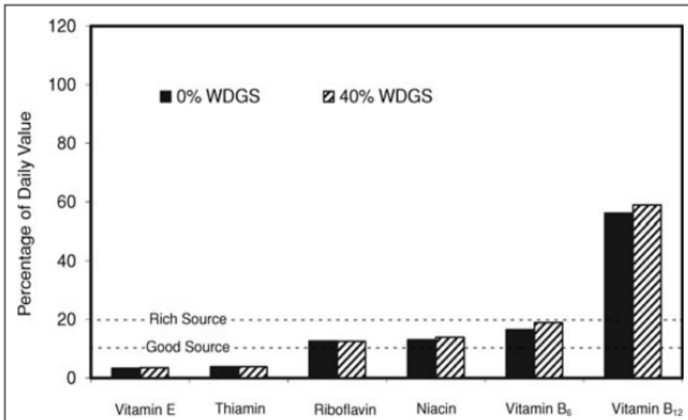

Figure 2–Percentage of vitamin Daily Values available through consumption of 100 g w/w of broiled petite tenders. WDGS = wet distiller's grains and solubles. These petite tenders had been graded as choice, separable lean only, and trimmed to 0" fat. The vitamin E (α-tocopherol) concentrations of broiled petite tenders from steers supplemented with vitamin E were significantly higher than for those from nonsupplemented steers (see Table 3).

vitamin concentrations in both meat cuts. Some significant differences in vitamin concentrations by cut in beef have been reported previously (Arnold and others 1992, 1993; Lahučký and others 2002; Lombardi-Boccia and others 2005; Gerber and others 2009). Variable fiber-type composition of muscles in the beef chuck and round has also been reported (Kirchofer and others 2003) and this likely influences the vitamin composition of the muscles.

The Daily Value is used in nutrient labeling of food products (USFDA 2008). The mean percentages of the Daily Values of the vitamins that would be provided in grilled and broiled flat iron steaks and broiled petite tenders, respectively, in the present study are given in Figure 1 and 2. According to USFDA (1992) regulations the terms "high," "rich in," or "major source of" should be used when a serving of food (in the case of meats, 100 g) contains 20% or more of the Reference Daily Intake (also referred to as Daily Values) for that nutrient, and that the terms "source," "good source of," or "important source of" be used when a serving of the food contains 10% to 19% of the Reference Daily Intake or Daily Value for that nutrient. Hence, cooked flat iron steaks and petite tenders from the beef steers in the present study would be considered to be rich sources of vitamin B_{12} and good sources of riboflavin, niacin, and vitamin B_6. Dietary consumption of these beef value cuts can contribute considerably to meeting the vitamin recommendations of humans.

Conclusions

Flat iron steaks and petite tenders from steers fed finishing rations containing 0% and 40% WDGS with and without supplemental vitamin E had similar cooking yields and times. Cooking yields were higher and cooking times were longer for flat iron steaks that were broiled than those grilled. Cooked cuts from these steers contained different, mostly significantly, quantities of the selected vitamins as compared to when the cuts were uncooked. Vitamin E concentrations of raw and cooked meat from steers that received vitamin E supplements during finishing were significantly higher than cuts from those fed basal levels of vitamin E; however, the concentrations of thiamin, riboflavin, niacin, vitamin B_6, and vitamin B_{12} were similar. WDGS consumption significantly influenced the thiamin, riboflavin, vitamin B_6, and vitamin B_{12} concentrations in raw flat iron steaks and vitamin B_6 in raw petite tenders. Broiled flat iron steaks contained significantly different quantities of thiamin, vitamin B_6, and vitamin B_{12} concentrations than those that were grilled. Although a few differences in vitamin concentrations of the flat iron steaks and petite tenders were observed by WDGS, vitamin E supplementation, and cooking treatments, most of the vitamin concentrations were statistically similar. These 2 beef value cuts as human food sources are rich sources of vitamin B_{12} and good sources of riboflavin, niacin, and vitamin B_6. Feeding beef steers diets containing 40% WDGS with and without vitamin E supplementation appeared to have minute effects on the vitamin content of cooked flat iron steaks and petite tenders from these steers. Thus beef producers can feed their steers finishing diets containing 40% WDGS without impacting the contributions of value meat cuts from these animals to the daily vitamin intakes of consumers and also need not supplement these steers with vitamin E.

Acknowledgments

The authors thank G. Mall, Tiurma V. Sinaga, and Eliza Halim for helping with the laboratory analyses. This research is a contribution of the Univ. of Nebraska Agricultural Research Div. and was supported in part by funds provided through the Hatch Act. Additional financial support was provided by The Beef Checkoff and the Nebraska Beef Council.

References

AOAC. 2006. Official methods of analysis. 18th ed. Arlington, Va.: Assoc. Off. Anal. Chem. 2000 p.

Arnold RN, Arp SC, Scheller KK, Williams SN, Schaefer DM. 1993. Tissue equilibration and subcellular distribution of vitamin E relative to myoglobin and lipid oxidation in displayed beef. J Anim Sci 71:105–18.

Arnold RN, Scheller KK, Arp SC, Williams SN, Buege DR, Schaefer DM. 1992. Effect of long- or short-term feeding of α-tocopheryl acetate to Holstein and crossbred beef steers on performance, carcass characteristics, and beef color stability. J Anim Sci 70:3055–65.

Chun J, Lee J, Ye L, Exler J, Eitenmiller RR. 2006. Tocopherol and tocotrienol contents of raw and processed fruits and vegetables in the United States diet. J Food Compos Anal 19:196–204.

Corrigan ME, Erickson GE, Klopfenstein TJ, Luebbe MK, Vander Pol KJ, Meyer NF, Buckner CD, Vanness SJ, Hanford KJ. 2009. Effects of corn processing method and corn wet distillers grains plus solubles inclusion level in finishing steers. J Anim Sci 87:4073–81.

Dawson KR, Unklesbay NF, Hedrick HB. 1988. HPLC determination of riboflavin, niacin, and thiamin in beef, pork, and lamb after alternate heat-processing methods. J Agric Food Chem 36:1176–9.

de Mello AS Jr, Calkins CR, Jenschke BE, Senaratne LS, Carr TP, Dugan MER, Erickson GE. 2008. Finishing diets containing wet distiller's grains plus solubles affect the fatty acid profiles of beef from calf-fed and yearling steers. Abstr 28, Reciprocal Meat Conference. Univ. Florida, Gainesville, Fla.

Dong MH, McGown EL, Schwenneker BW, Sauberlich HE. 1980. Thiamin, riboflavin and vitamin B6 contents of selected foods as served. J Am Diet Assoc 76:156–60.

Dowdy S, Wearden S, Chilko D. 2004. Statistics for research. 3rd ed. Hoboken, N.J.: John C. Wiley & Sons Inc. p 372–81.

Driskell JA, Yuan X, Giraud DW, Hadley M, Marchello MJ. 1997. Concentrations of selected vitamins and selenium in bison cuts. J Anim Sci 75:2950–4.

Driskell JA, Marchello MJ, Giraud DW. 2000. Riboflavin and niacin concentrations of bison cuts. J Anim Sci 78:1267–71.

Faustman C, Cassens RG, Schaefer DM, Buege DR, Williams SN, Scheller KK. 1989. Improvement of pigment and lipid stability in Holstein steer beef by dietary supplementation with vitamin E. J Food Sci 54:858–62.

Gerber N, Scheeder MRL, Wenk C. 2009. The influence of cooking and fat trimming on the actual nutrient intake from meat. Meat Sci 81:148–54.

Granit RS, Angel S, Arkik B, Holzer Z, Aharoni Y, Orlov A, Kanner J. 2001. Effects of vitamin E supplementation on lipid peroxidation and color retention of salted calf muscle from a diet rich in polyunsaturated fatty acids. J Agric Food Chem 49:5951–6.

Gregory JF III, Manley DB, Kirk JR. 1981. Determination of vitamin B-6 in animal tissues by reversed-phase high-performance liquid chromatography. J Agric Food Chem 29:921–7.

Halpin CG, Harris DJ, Caple IW, Patterson DS. 1984. Contribution of cobalamin analogues to plasma vitamin B_{12} concentrations in cattle. Res Vet Sci 37:249–53.

Hidiroglou N, LaFamme LF, McDowell LR. 1988. Blood plasma and tissue concentrations of vitamin E in beef cattle as influenced by supplementation of various tocopherol compounds. J Anim Sci 66:3227–34.

[IMNAS] Inst. of Medicine, Natl. Academy of Sciences. 2000. Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoids. Washington, D.C.: Natl. Academy Press. p 186–283.

Kim YN, Giraud DW, Driskell JA. 2007. Tocopherol and carotenoid contents of selected Korean fruits and vegetables. J Food Compos Anal 20:458–65.

Kim YN, Giraud DW, Driskell JA. 2009. Vitamins. In: Nollet LML, Toldrá F, editors. Handbook of muscle foods analysis. Boca Raton, Fla.: CRC Press. p 419–39.

Kirchgessner M, Roth-Maier DA, Heindl U, Schwarz FJ. 1995. B-Vitamine (Thiamin, Vitamin B_6 und Pantothensäure) im Muskelgewebe wachsender Rinder der Rasse deutsches Fleckeviehs n Abhängigkeit von Mastendmasse und Fütterungsintensität. Z Lebensm Unters Forsch 201:20–4.

Kirchhofer KS, Calkins CR, Gwartney BL. 2003. Fiber-type composition of muscles of the beef chuck and round. J Anim Sci 80:2872–8.

Klopfenstein T. 2001. Distillers grains for beef cattle. Louisville, K.Y.: Distillers Grains Technology Council. Available from: http://www.distillersgrains.org/feedsource/beef_cattle.html. Accessed Apr 25, 2008.

Lahučký RK, Novotná K, Kaujec J, Mojto M, Pavlič, Blanco Roa NE. 2002. Vplyvv prídavku vitamínu E v krmive na obsah α-tokoferolu a antioxidačný stav vo svaloch jatočných býkov. Czech J Anim Sci 47:381–6.

Liu Q, Lanari MC, Schaefer DM. 1995. A review of dietary vitamin E supplementation for improvement of beef quality. J Anim Sci 73:3131–40.

Lombardi-Boccia G, Lanzi S, Aguzzi A. 2005. Aspects of meat quality: trace elements and B vitamins in raw and cooked meats. J Food Compos Anal 18:39–46.

MacPhearson A, Chalmers JS. 1984. Effect of dietary energy concentration on the cobalt/vitamin B_{12} requirements of growing calves. In: Mills CF, Bremmer I, Chesters JK, editors. Trace element metabolism in animals, no. 5. Slough, U.K.: Commonwealth Agricultural Bureaux. p 145.

McCay PB, King MM. 1980. Vitamin E: Its role as a biologic free radical scavenger and its relationship to the microsomal mixed function oxidase system. In: Machlin LJ, editor. Vitamin E: comprehensive treatise. New York: Marcel Dekker. p 289–317.

McDowell LR. 1989. Vitamins in animal nutrition: comparative aspects to human nutrition. San Diego, Calif.: Academic Press. 486 p.

Murphy EW, Criner PE, Gray BC. 1975. Comparison of methods for determining retentions of nutrients in cooked foods. J Agric Food Chem 23:1153–7.

[NRCNAS] Natl. Research Council, Natl. Academy of Sciences. 2000. Nutrient requirements of beef cattle. 7th ed. (Update 2000). Washington, D.C.: Natl. Academy Press. 232 p.

[NAMPA] North American Meat Processors Assoc. 2006. The meat buyers guide: beef, lamb, veal, pork, and poultry. Hoboken, N.J.: John Wiley & Sons. 336 p.

O'Grady MN, Monahan FJ, Fallon RJ, Allen P. 2001. Effects of dietary supplementation with vitamin E and organic selenium on the oxidative stability of beef. J Anim Sci 79:2827–34.

Sanders SK, Morgan JB, Wulf DM, Tatum JD, Williams SN, Smith GC. 1997. Vitamin E supplementation of cattle and shelf-life of beef for the Japanese market. J Anim Sci 75:2634–40.
Sauberlich HE. 1967. Vitamin B_6. In: György P, Pearson WN, editors. The vitamins: chemistry, physiology, pathology, method. 2nd ed. New York: Academic Press. p 169–77.
Tappel AL. 1972. Vitamin E and free radical peroxidation of lipids: vitamin E and its role in cellular metabolism. Ann NY Acad Sci 203:12–23.
USDA. 2003. Table of nutrient retention factors. Release 2003. Washington, D.C.: USDA. Available from: http://www.usda.gov/ba/bhnrc/ndl. Accessed Aug 3, 2009.
USDA. 2008. USDA national nutrient database for standard reference. Release 18. Washington, D.C.: USDA. Available from: http://www.usda.gov/ba/bhnrc/ndl. Accessed Aug 3, 2009.
USDA, ARS. 2007. USDA table of nutrient retention factors. Release 6. Beltsville, Md.: USDA, ARS. Available from: http://www.ars.usda.gov/nutrient data. Accessed Oct 2, 2009.
USDA, ARS. 2009. What we eat in America, NHANES, 2005–2006. Washington, D.C.: USDA, ARS. Available from: http://www.ars.usda.gov/ba/bhnrc/fsrg. Accessed July 3, 2009.
USDA, Food Safety and Inspection Service. 2003. Fact sheets – meat preparation: beef ... from farm to table. Washington, D.C.: USDA, Food Safety and Inspection Service. Available from: http://www.fsis.usda.gov/factsheets/Beef_from_Farm_to_Table/index.asp. Accessed Aug 3, 2009.
[USFDA] U.S. Food and Drug Administration. 2008. Guidance for industry: a food labeling guide. Washington, D.C.: Food and Drug Administration. Available from: http://www.cfsan.fda.gov/~dms/21g-toc.html. Accessed May 13, 2009.
[USFDA] U.S. Food and Drug Administration. 1992. Food labeling: nutrient content claims, general principles, petitions, definitions of terms; Definitions of nutrient content claims for the fat, fatty acid, and cholesterol content of food. Fed Reg December 17 (58 FR 2302).
Vander Pol KJ, Luebbe MK, Crawford GI, Erickson GE, Klopfenstein TJ. 2009. Performance and digestibility characteristics of finishing diets containing distillers grains, a composite of corn coproducts, or supplemental corn oil. J Anim Sci 7:639–52.
Walker CK, Elliot JM. 1972. Lactational trends in vitamin B_{12} status on conventional and restricted-roughage rations. J Dairy Sci 55:474–9.
Yang JA, Sulaeman A, Setiawan B, Atughonu A, Giraud D, Driskell JA. 1994. Sensory qualities and nutrient retention of beef strips prepared by different household cooking techniques. J Am Diet Assoc 94:199–201.
Yuan X, Marchello MG, Driskell JA. 1999. Selected vitamin contents and retentions in bison patties as related to cooking method. J Food Sci 64:462–4.
Zerby HN, Belk KE, Sofos JN, McDowell LR, Smith GC. 1999. Case life of seven retail products from beef cattle supplemented with alpha-tocopheryl acetate. J Anim Sci 77:2458–63.

Effect of Cooking Method, Distiller's Grains, and Vitamin E Supplementation on the Vitamin Content of Value Cuts from Beef Steers FedWet Distiller's Grains and Solubles and Supplemental Vitamin E

ORIGINALITY REPORT

10%	6%	8%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	archive.org Internet Source	1%
2	www.tandfonline.com Internet Source	1%
3	Submitted to Drexel University Student Paper	1%
4	Benoît Graulet, Christiane L. Girard. "B Vitamins in Cow Milk", Elsevier BV, 2017 Publication	1%
5	J L CRACOWSKI. "Increased formation of F2-isoprostanes in patients with severe heart failure", Heart, 10/1/2000 Publication	<1%
6	Eitenmiller, Ronald. "Dietary Vitamin E Supplementation for Improvement of Oxidative Stability of Muscle Foods, Milk, and Eggs", Food Science and Technology, 2004.	<1%

Publication

7	Submitted to University of Arizona Student Paper	<1%
8	L-H Wang. "Bacillary dysentery as a causative factor of irritable bowel syndrome and its pathogenesis", Gut, 8/1/2004 Publication	<1%
9	Submitted to The University of the South Pacific Student Paper	<1%
10	S K Sanders, J B Morgan, D M Wulf, J D Tatum, S N Williams, G C Smith. "Vitamin E supplementation of cattle and shelf-life of beef for the Japanese market.", Journal of Animal Science, 1997 Publication	<1%
11	naldc.nal.usda.gov Internet Source	<1%
12	Alessandra Bordoni, Francesca Danesi, Mattia Di Nunzio, Annalisa Taccari, Veronica Valli. "Ancient wheat and health: a legend or the reality? A review on KAMUT khorasan wheat", International Journal of Food Sciences and Nutrition, 2016 Publication	<1%
13	"Quality Attributes and their Measurement in Meat, Poultry and Fish Products", Springer	<1%

Science and Business Media LLC, 1994

Publication

14	inba.info Internet Source	<1%
15	www.slideshare.net Internet Source	<1%
16	F Hadj-Saad, M Lhuissier, J.-C Guilland. "Effects of acute, submaximal exercise on vitamin B6 metabolism in the rat", Nutrition Research, 1995 Publication	<1%
17	P. L. Loza, C. D. Buckner, K. J. Vander Pol, G. E. Erickson, T. J. Klopfenstein, R. A. Stock. "Effect of feeding combinations of wet distillers grains and wet corn gluten feed to feedlot cattle", Journal of Animal Science, 2009 Publication	<1%
18	Lee Russell McDowell. "Vitamins in Animal and Human Nutrition", Wiley, 2000 Publication	<1%
19	www.publish.csiro.au Internet Source	<1%
20	Kil Sun Yoo. "Quantification of Quercetin Glycosides in 6 Onion Cultivars and Comparisons of Hydrolysis-HPLC and Spectrophotometric Methods in Measuring Total	<1%

Quercetin Concentrations", Journal of Food Science, 03/2010
Publication

21 Jung Hoon Lee, John C. Waller, Sharon L. Melton, Arnold M. Saxton. " Incorporation of α-Tocopherol and Linoleic Acid in Fresh Lambs by Feeding Chemically Treated Dietary Supplements Containing -α-Tocopheryl Acetate and Sunflower Oil ", Journal of Agricultural and Food Chemistry, 2006 <1%
Publication

22 Kim, Y.-N.. "Tocopherol and carotenoid contents of selected Korean fruits and vegetables", Journal of Food Composition and Analysis, 200709 <1%
Publication

23 Veracini, J.L., P.M. Walker, M.J. Faulkner, R.E. Hall, R.L. Atkinson, and B.R. Wiegand. "Effects of high fat, modified wet, corn distiller's grains plus solubles on beef steer performance and carcass characteristics", Livestock Science, 2013. <1%
Publication

24 www.cazv.cz <1%
Internet Source

25 academic.oup.com <1%
Internet Source

26 J.B. Lawlor. "Measuring Oxidative Stability of Beef Muscles Obtained from Animals Supplemented with Vitamin E Using Conventional and Derivative Spectrophotometry", Journal of Food Science, 10/2000 <1%
Publication

27 "Subject Index", LWT - Food Science and Technology, 200012 <1%
Publication

28 A. Watanabe. "Effects of Alpha-Tocopherol on Lactones in Beef Headspace during Storage", Journal of Food Science, 11/2010 <1%
Publication

29 www.scribd.com <1%
Internet Source

30 eprints.uniss.it <1%
Internet Source

31 Linong Ji, Ping Han, Xiaoyue Wang, Jingdong Liu et al. "Randomized clinical trial of the safety and efficacy of sitagliptin and metformin co-administered to Chinese patients with type 2 diabetes mellitus", Journal of Diabetes Investigation, 2016 <1%
Publication

32 T KATSURAGI. "Cerebrospinal fluid manganese <1%

concentrations in patients with symmetric pallidal hyperintensities on T1 weighted MRI", Journal of Neurology Neurosurgery & Psychiatry, 04/01/1999

Publication

Exclude quotes	On	Exclude matches	< 10 words
Exclude bibliography	On		