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Impact of DDGS-supplemented diet with or without vitamin E and selenium supplementation on the fatty acid profile of beef

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Abstract. The impact of supplementation of vitamin E or organic selenium in DDGS (dried distillers grains with solubles) diet on fatty acid composition in two meat cuts of finishing Holstein bulls was investigated. Twenty-four Holstein bulls were allotted to treatments in three groups of eight bulls per group for a 100-day trial. The treatments were adequate Se and vitamin E supplementation in control group (C), supranutritional vitamin E supplementation in vitamin Group E (E), supranutritional Se

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supplementation in selenium group (Se). At similar age, slaughtering Group C had higher slaughter/carcass weight and EUROP fat score than Se counterparts. The killing out percentage and proximate composition of muscles differed among treatments. Inclusion of the vitamin E or Se supplement led to expected increases ($P < 0.05$) in vitamin E and Se contents of the brisket and loin. Higher vitamin E concentration caused significant lower SFA and greater PUFA. Higher Se level influenced significant SFA in brisket and PUFA in both muscles. Vitamin E or Se dietary treatments in DDGS-supplemented diet resulted in beef meat cuts considerably beneficial PUFA/SFA but markedly higher n-6/n-3 PUFA ratio and even higher health index in both meat samples opposite to Group C.

1 Introduction

Vitamin E and Se are important components of the antioxidant defence system of living animals. After slaughter, they delay the onset of oxidation reactions in meat products. Supplementing cattle diet with vitamin E for 100 days in the last finishing period has been recognized as an effective tool for improving the appearance of beef cuts and results less lipid oxidation during retail display, while vitamin E supplementation had no significant effect on feedlot performance and carcass quality (*Kobayashi & Takasaki*, 1985, *Arnold et al.*, 1992).

Increased selenium (Se) intakes are associated with reduced risks of certain cancers in humans and an adequate intake is needed to decrease the risk of several diseases and other selenium deficiency syndromes. The Se concentration of meat is primarily determined by its geographical origin. Hungary belongs to the selenium-deficient regions in Europe; therefore, the improvement of Se supply of the population through increasing the Se content of animal products is desired. Se increments in muscle strongly depend on dietary level and the chemical form of Se (*Lee et al.*, 2006, *Cozzi et al.*, 2011). Otherwise, beef is a major natural source of dietary selenium for humans and is considered as a "highly bioavailable" compound (*Shi & Spallholz*, 1994). Due to the above mentioned beneficial effects, supplementation of animal diets with vitamin E and Se has been strongly proposed as a production strategy in cattle production.

The use of dried distiller's grains with solubles (DDGS) in cattle diets has increased in recent years. Feeding diets containing 0–30% DDGS in the finishing period either do not change (*Leupp et al.*, 2009) or change (*Mapiye et al.*, 2012) performance traits and yield of beef carcasses. Corn-based DDGS have some positive effects on meat quality compared to barley control diet

(*Aldai et al.*, 2010). Previous reports showed that DDGS appears to alter fatty acid profile and resulted a higher PUFA/SFA ratio in beef (*Depenbusch et al.*, 2008).

On the other hand, it should be considered that a higher proportion of PUFA (pro-oxidant) has negative influence on the oxidative stability of beef. This later depends on the balance between pro- and antioxidant components. The balance between the pro- and antioxidant compounds in beef can be provided by antioxidant supplementation, with the dietary inclusion of antioxidants such as vitamin E and Se. Knowing the exact effect of supplementations on carcass value is essential upon the introduction of a novel feeding system.

As a consequence of this, the main aim of the present work was to determine the influence of DDGS-supplemented diet with or without vitamin E and selenium on the fatty acid profile of beef in order to evaluate meat quality.

2 Materials and methods

2.1 Materials

Animals and diet

Experiments were conducted on a private commercial cattle-fattening farm (Bull Farms Ltd., Csengele). Twenty-four Holstein young bulls were included in the experiment. Animals were allotted randomly to one of three dietary treatments, with 8 animals per treatments. All of the animals were fattened under semi-intensive conditions, ad libitum maize silage, grass hay, and moderate concentrate. The diet was supplemented with 20% DDGS (*Table 1*).

Table 1: Ingredients of the dietary treatments

On DM basis, %	Group E	Group Se	Control
Maize silage	40	40	40
Grass hay	10	10	10
Concentrate	30	30	30
DDGS	20	20	20
Premix with selenium	-	+	-
Drinking water with vitamin E	+	-	-

Treatments included vitamin E supplementation (Lutavit E50, BASF) for vitamin Group E (E). Lutavit E 50 S water dispersible powder was administered directly via the drinking water. Animals in Group E received drinking water

containing 2 mg of Lutavit E/day/animal.

Selenium supplementation was carried out by adding selenium-enriched yeast (Selplex-2300 Saccharomyces cerevisiae CNCM, I-3060 Alltech) for the Selenium (Se) group. We prepared a premix using ground corn grain in a way that 10 g of the premix contained 2 mg of selenium in order to ease the administration. This premix was added to the daily feed of the cattle in Group Se.

The bulls in Group C received sufficient vitamin E and Se as the requirement for growing cattle. The length of the experimental period was 100 days. The average final weight and age of bulls were 499±67 kg and 502±87 day, respectively.

2.2 Methods

Slaughter procedure, meat sampling

The animals were slaughtered at similar live weight at the commercial abattoir according to the Hungarian Standard. The carcasses were assessed for conformation (an 18-point scale: scale 1 (poorest) to 18 (best)) and fatness (a 15 point-scale: scale 1 (leanest) to 15 (fattest)) according to the EU beef carcass classification scheme with the use of subclasses. One hour after the slaughter, the dressed carcasses were weighed (hot carcass weight). After 24 hours, chilling samples were taken from the right half carcass from two commercial meat cuts (brisket, loin) from muscles (*superficial pectoral* (SP), and *longissimus dorsi* (LD) muscles) to determine the vitamin E and selenium content as well as the fatty acid profile of beef. The *superficial pectoral* muscle was trimmed from boneless brisket. Longissimus dorsi muscle was separated from thoracic vertebrae between the 12^{th} and 13^{th} ribs.

Chemical analysis, determination of vitamin E and selenium content, and the fatty acid profile of muscles

Laboratory examinations were carried out in the Analytical Laboratory of Kaposvár University, Faculty of Agricultural and Environmental Sciences. The chemical composition, selenium content, and fatty acid profile were determined as previously described (*Holló et al.*, 2008). The Se-content determination is based on the method written in the Hungarian Food Codex (HFC, 1990). Total vitamin E concentration in muscles was measured according to the method by *Csapó & Csapó-Kiss* (2003).

Proportions of fatty acids were expressed as a percentage of total fatty acid methyl esters. Besides individual fatty acids, 7 groups of fatty acids were calculated. Health Index (HI) was calculated as previously described by *Zhang*

et al. (2008). HI = (Total MUFA + Total PUFA) / (4 × C14 : 0 + C16 : 0).

Statistical analysis

For the statistical evaluation, the IBM SPSS 20.0 software (2011) was used. In addition to basic statistical results (mean, SD), the effect of diet was evaluated with multivariate analysis of variance, general linear model (GLM) III. The differences between the groups were evaluated with LSD test – the level of significance was set at $P < 0.05$. In Table 3, significance level at $P < 0.1$ was shown, too.

3 Results and discussion

Carcass characteristics

At similar slaughtering age, Group C had the highest slaughter weight regarding hot carcass weight (*Table 2*).

Table 2: Effect of dietary supplement on the carcass value of beef from bulls fed DDGS diets

Components	Slaughter weight, kg	Hot carcass weight, kg	Killing out, %	EUROP meat score, point	EUROP fat score, point
E	496.13±44.16^{ab}	256.95±30.54^{ab}	51.70±2.11^{a}	6.75±1.98	3.38 ± 0.74^{ab}
Se	464.00±56.27^{a}	242.68±34.64^{a}	52.22±2.31^{a}	7.13±1.36	3.00 ± 0.00^{a}
C	536.13±81.07^{b}	294.78±48.87^{b}	54.88±2.60^{b}	8.13±1.81	4.38 ± 1.41^{b}
Mean	498.75±66.83	264.80±43.36	52.94±2.66	7.33±1.76	3.58±1.06

^{a,b} means significant differences among groups

Group Se showed significantly lower slaughter and carcass weight than the other two groups. Carcass dressing percentage was 53% and the majority of carcasses were classified into conformation class R – and to fat classes 2 – (Group C) and 1+ (Group E and Se). Dietary vitamin E did not affect hot carcass weight and EUROP grading, but dressing percentage was affected, in line with previous findings (*Nassu et al.*, 2011). Similarly to Group E, the dietary inclusion of Se resulted lower killing out percentage in Group Se, and, what is more – mainly due to lower carcass weight –, a significantly lower EUROP fat grade than in Group C. In literature, it is generally reported that Se and vitamin E contents of diets did not affect carcass characteristics, but the effects of supplementation depend on its level and type of source, previous nutritional history, and handling of animals (*Cozzi et al.*, 2011, *Nassu et al.*, 2011).

Proximate composition

The protein, fat, and ash content on dry matter basis showed significant differences in both muscles between control and supplemented groups. The intramuscular fat contents of loin in supplemented groups are considerably lower than the content of 2 to 2.5% reported to be optimal for beef-eating quality. Intramuscular fat content in longissimus muscle of Charolais young bulls showed a similar trend (*Cozzi et al.*, 2011); however, there were no significant differences among Se treatments. The dietary treatment effect on protein content of muscles was significant; the highest protein level was measured in Group E. A significant difference was observed for ash content between muscles; in brisket, it was measured a higher level than in loin. Higher ash contents were recorded from Se- or vitamin-E-supplemented groups in both muscles.

Muscle vitamin E and Se content

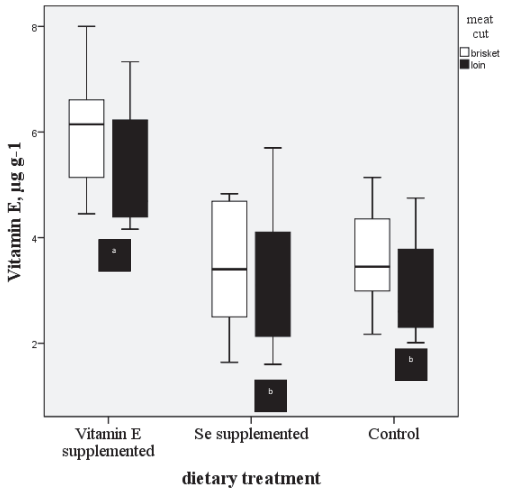
The vitamin E supplementation resulted in higher vitamin E concentrations in meat cuts (*Figure 1*). In agreement with the previous findings, vitamin E concentration in Group E was more than 1.5-fold greater than that measured in Group C (brisket: 6.1 *vs.* 3.6 μg g^{-1}; loin: 5.2 *vs.* 3.1 μg g^{-1}). It was found that vitamin E level in muscle is significantly higher in beef fed WDGS diet supplemented daily with vitamin E than that of the non-supplemented group (*Driskell et al.*, 2011). In line with the results of *O'Grady et al.* (2001), muscle vitamin E concentrations were not significantly affected by dietary Se supplementation (brisket: 3.5 *vs.* 3.6 μg g^{-1}; loin: 3.3 *vs.* 3.1 μg g^{-1}). The oxidative stability can be influenced effectively if vitamin E content in beef reached 3–3.5 μg g^{-1} (*Arnold et al.*, 1993). Both muscles in Group E contained a vitamin E level above the mentioned threshold value.

Table 3: Effect of dietary supplement on chemical composition (on DM basis, except for DM) of beef from bulls fed DDGS diets

Compo-nents	Dry matter, %		Protein, DM%		Fat, DM%		Ash, DM%	
	brisket	loin	brisket	loin	brisket	loin	brisket	loin
E	24.76 ± 2.09^{ab}	24.40 ± 1.36	88.68 ± 6.27^{a}	92.54 ± 1.92^{a}	6.54 ± 4.00^{b}	3.74 ± 2.02^{b}	4.19 ± 0.43^{a}	3.72 ± 0.34^{a}
Se	24.03 ± 0.89^{b}	23.91 ± 1.44	87.72 ± 3.9^{ab}	92.13 ± 1.92^{a}	7.20 ± 3.96^{b}	3.99 ± 1.91^{b}	4.27 ± 0.20^{a}	3.87 ± 0.33^{a}
C	26.67 ± 2.63^{a}	23.58 ± 2.72	81.29 ± 9.27^{b}	88.02 ± 3.94^{b}	14.93 ± 9.76^{a}	8.67 ± 4.11^{a}	3.60 ± 0.67^{b}	3.31 ± 0.31^{b}
Mean	25.15 ± 2.23	23.97 ± 1.89	$85.90\pm7.35^{*}$	$90.90\pm3.37^{**}$	$9.56\pm5.91^{*}$	$5.47\pm3.58^{**}$	$4.02\pm0.54^{*}$	$3.63\pm0.40^{**}$

^{a,b} means significant differences among groups

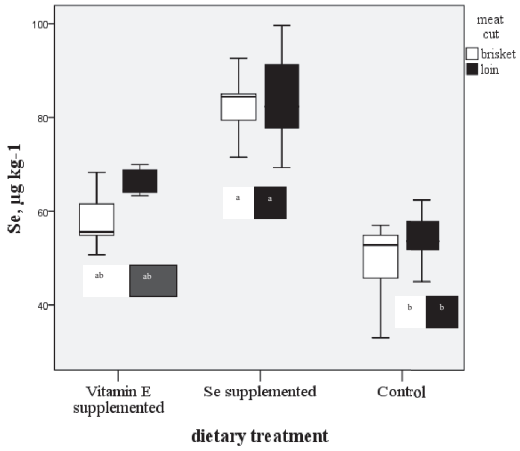
*,** means significant differences between muscles $P < 0.05$



[a,b] means significant differences among groups $P < 0.05$

Figure 1: Effect of dietary supplement on Vitamin E content of beef from bulls fed DDGS diet

As expected, Group Se had significantly higher concentrations of Se in muscles (Se: 83.42 µg kg^{-1}) than those not receiving dietary supplementation (E: 61.72 µg kg^{-1} and C: 51.73 µ kg^{-1}) (*Figure 2*).



[a,b] means significant differences among groups $P < 0.05$

Figure 2: Effect of dietary supplement on Se content of beef from bulls fed DDGS diet

There were significantly higher concentrations of Se in muscles of Group Se (82.58±7.79 μ kg^{-1} and 83.94±9.81 μ kg^{-1}) compared to Group C (49.14±8.49 μ kg^{-1} 54.32±5.95 μ kg^{-1}), whereas intermediate Se concentration (58.20±6.84 μ kg^{-1}, 65.82+2.83 μ kg^{-1}) was found in muscles of Group E. Higher Se concentration was observed in loin (longissimus muscle: 68.89±14.63 μ kg^{-1}) than in brisket (pectoralis muscle: 61.23±15.50 μ kg^{-1}), although the difference was not significant.

Fatty acid profile of muscles

The results of total fatty acid composition are presented in *Table 4*. Treatment differences in fatty acid composition were mainly for supplemented versus non-supplemented groups in both muscles. In vitamin-E- and Se-supplemented groups, decreased proportions of SFA and higher levels of PUFA can be observed. Briskets from Group C tended to have the highest SFA content, too, due to higher intramuscular fat content. These differences can be largely attributed to increased levels of myristic and palmitic acids as well as to a higher percentage of C 12:0, C 15:0, and C 17:0 in the brisket of control group. From human nutritional point of view, the lauric (C12:0), myristic (C14:0), and palmitic (C16:0) acids deserve attention. These are the primary fatty acids associated with increasing plasma low-density lipoprotein and cholesterol concentrations in humans. Palmitic acid (C 16:0) is the main end-product of de novo fatty-acid synthesis; this can be elongated to stearic (C 18:0) acid. The C 18:0 is the main end-product of linoleic (C 18:2 *n*-6) and linolenic acid (C 18:3 *n*-3) biohydrogenation process, too. In our study, a lower ($P < 0.1$) C 18:0 was measured in the brisket of control bulls than in Group Se. In line with stearic acid content, the long-chain saturated fatty acids (C 20:0, C 21:0, C 22:0) were found in a significantly higher proportion in both muscles of Se group compared to control group. It seems that biohydrogenation in Group Se was higher than in the other two groups. The average SFA content of loin in Group C significantly differed from the SFA detected in vitamin Group E. The same individual saturated fatty acid differences were detected between dietary treatments for loin as well as for brisket, except for C 17:0 and C 18:0. The MUFA content of muscles varied between 39 and 43%; significant differences were detected for C 14:1, C16:1, and C 20:1 fatty acids. In this study, C 18:1 *trans* isomers were found in a significantly higher proportion in supplemented groups than that of the muscles in control group. Contrary to *trans* isomers, in the loin of control group, a higher level of C 18:1 *cis* fatty acid was observed than in Group Se. *Cis-9*, *trans*-11 CLA (conjugated linoleic acid) are considered highly beneficial to human health.

Table 4: Effect of dietary supplement on the fatty acid profile of intramuscular fat from the brisket and loin of bulls fed DDGS diets

Item	E		Se		C		Total	
	brisket	loin	brisket	loin	brisket	loin	brisket	loin
C10:0	0.03±0.0	0.02±0.0	0.02±0.0	0.02±0.0	0.03±0.0	0.03±0.0	0.02±0.0	0.02±0.0
C12:0	0.04±0.0^{b}	0.03±0.0^{b}	0.03±0.0^{b}	0.03±0.0^{b}	0.05±0.0^{a}	0.05±0.0^{a}	0.04±0.0	0.04±0.0
C13:0	0.01±0.0	0.01±0.0	0.01±0.0	0.01±0.0	0.02±0.0	0.01±0.0	0.01±0.0	0.01±0.0
C14:0	1.98±0.6^{b}	1.61±0.5^{b}	1.65±0.5^{b}	1.58±0.2^{b}	3.01±0.5^{a}	2.65±0.6^{a}	2.21±0.8	1.90±0.7
C14:1	0.28±0.2^{b}	0.24±0.1^{ab}	0.22±0.1^{b}	0.19±0.1^{b}	0.56±0.2^{a}	0.40±0.2^{a}	0.35±0.2	0.27±0.2
C15:0	0.36±0.1^{b}	0.41±0.1^{b}	0.43±0.1^{b}	0.51±0.1^{ab}	0.57±0.1^{a}	0.58±0.1^{a}	0.45±0.1	0.49±0.1
C16:0	24.14±4.0^{b}	22.02±3.1^{b}	22.22±2.3^{b}	21.91±1.2^{b}	28.50±1.8^{a}	27.18±2.5^{a}	24.95±3.8	23.46±3.3
C16:1	2.39±0.5^{ab}	2.32±0.5^{ab}	1.99±0.4^{b}	1.84±0.4^{b}	2.88±0.7^{a}	2.39±0.4^{a}	2.42±0.6	2.18±0.5
C17:0	1.08±0.1^{b}	1.17±0.2	1.23±0.2^{ab}	1.32±0.2	1.26±0.2^{a}	1.29±0.2	1.19±0.2	1.25±0.2
C17:1	0.57±0.1	0.68±0.1	0.59±0.1	0.60±0.1	0.59±0.1	0.59±0.1	0.59±0.1	0.63±0.1
C18:0	20.49±0.9^{AB}	20.07±1.0	22.35±3.3^{A}	23.75±4.0	19.43±4.0^{B}	19.95±3.3	20.76±3.1	21.26±3.3
C18:1 t-1	2.32±0.5^{ab}	2.94±1.1	2.68±0. 9^{a}	3.04±0.9	1.81±0.3^{b}	1.89±0.3	2.27±0.7	2.67±1.0
C18:1 t-2	1.67±0.2^{a}	1.79±0.2^{a}	1.55±0.2^{ab}	1.55±0.2^{b}	1.41±0.1^{b}	1.49±0.1^{b}	1.54±0.2	1.62±0.2
C18:1*n*-9c	33.30±2.8	33.66±2.7^{ab}	34.16±2.2	31.60±2.0^{b}	35.70±2.8	35.67±3.3^{a}	34.39±2.7	33.55±3.0
C18:2*n*-6	5.88±2.8^{a}	7.14±2.3^{a}	5.90±1.7^{a}	6.81±1.6^{a}	2.45±0.5^{b}	3.39±0.8^{b}	4.75±2.5*	5.95±2.4**
C20:0	0.21±0.1^{b}	0.20±0.0^{ab}	0.29±0.1^{a}	0.27±0.1^{a}	0.18±0.1^{b}	0.18±0.1^{b}	0.23±0.1	0.22±0.1
C18:3*n*-6	0.03±0.0	0.04±0.0	0.03±0.0	0.04±0.0	0.03±0.0	0.03±0.0	0.03±0.0*	0.04±0.0**
C20:1	0.22±0.2^{a}	0.27±0.2^{a}	0.19±0.1^{a}	0.21±0.1^{a}	0.03±0.0^{b}	0.07±0.1^{b}	0.15±0.2	0.19±0.1
C18:3*n*-3	0.39±0.1^{B}	0.44±0.1^{b}	0.46±0.3^{AB}	0.46±0.1^{b}	0.56±0.1^{A}	0.70±0.1^{a}	0.47±0.2	0.52±0.2
c-9,t-11 KLS	0.29±0.1	0.34±0.1^{C}	0.40±0.1	0.41±0.1^{A}	0.35±0.1	0.35±0.1^{B}	0.35±0.1	0.36±0.1
C21:0	0.03±0.0^{ab}	0.03±0.0^{ab}	0.04±0.0^{a}	0.04±0.0^{a}	0.02±0.0^{b}	0.02±0.0^{b}	0.03±0.0	0.03±0.0
C22:0	0.05±0.0^{ab}	0.04±0.0^{ab}	0.06±0.0^{a}	0.05±0.0^{a}	0.03±0.0^{b}	0.03±0.0^{b}	0.05±0.0	0.04±0.0
C20:4*n*-6	2.81±2.5^{a}	3.04±1.5^{a}	2.18±1.2^{a}	2.50±1.2^{a}	0.21±0.3^{b}	0.56±0.7^{b}	1.74±1.9	2.15±1.6
C23:0	0.05±0.0^{ab}	0.06±0.0^{a}	0.06±0.0^{a}	0.04±0.0^{ab}	0.02±0.0^{b}	0.02±0.0^{b}	0.04±0.0	0.04±0.0
C22:5*n*-3	0.60±0.4^{a}	0.61±0.3^{a}	0.53±0.3^{a}	0.50±0.2^{ab}	0.09±0.1^{b}	0.20±0.1^{b}	0.41±0.4	0.46±0.3
C22:6*n*-3	0.04±0.0^{a}	0.05±0.0^{a}	0.03±0.0^{ab}	0.04±0.0^{ab}	0.01±0.0^{b}	0.02±0.0^{b}	0.03±0.0	0.03±0.0
SFA	48.36±4.6^{b}	45.66±3.5^{b}	48.28±4.5^{b}	49.54±4.7^{ab}	53.00±3.1^{a}	51.98±2.8^{a}	49.88±4.5	48.76±4.5
MUFA	40.67±3.2	41.77±2.0	41.34±3.0	38.94±2.6	43.07±3.4	42.54±3.4	41.70±3.2	41.05±3.0
PUFA	10.86±6.4^{a}	12.57±4.4^{a}	10.27±3.4^{a}	11.52±3.4^{a}	3.83±0.8^{b}	5.49±1.8^{b}	8.32±5.2	10.20±4.5
n-6	9.31±5.8^{a}	10.85±4.0^{a}	8.61±3.1^{a}	9.88±2.9^{a}	2.77±0.8^{b}	4.13±1.6^{b}	6.90±4.7	8.61±4.2
n-3	1.25±0.7^{A}	1.36±0.5	1.22±0.7^{AB}	1.20±0.4	0.69±0.1^{B}	0.99±0.3	1.05±0.6	1.20±0.4
PUFA/SFA	0.24±0.2^{a}	0.28±0.1^{a}	0.22±0.1^{a}	0.24±0.1^{a}	0.07±0.0^{b}	0.11±0.0^{b}	0.18±0.1	0.22±0.1
n-6/*n*-3	7.52±2.0^{a}	8.08±2.2^{a}	7.97±2.6^{a}	8.44±1.2^{a}	4.03±0.9^{b}	4.11±0.6^{b}	6.51±2.6	7.06±2.4
HI	1.70±0.6^{a}	1.98±0.5^{a}	1.84±0.4^{a}	1.80±0.3^{a}	1.16±0.1^{b}	1.29±0.2^{b}	1.57±0.5	1.72±0.4

^{a,b} means significant differences among groups P < 0.05
A, B means significant differences among groups P < 0.01
*,** means significant differences between muscles P < 0.05

This fatty acid differed ($P < 0.1$) among treatments in the case of loin; the highest was in the Se-group, followed by Group C, and the lowest was in Group E. Based on our data, Se supplementation might improve the proportion of CLA level in loin.

The linoleic acid proportion was more than 2-fold higher in supplemented groups. Significant muscle effect on fatty acid composition was detected only for C 18:2 *n*-6 and C 18:3 *n*-6 fatty acids. The linolenic acid (C 18:3 *n*-3) content was higher in the brisket and the loin of Group C compared to the same values of Group E and the value of loin detected in Group Se. The long-chain fatty acids belonging to *n*-3 and *n*-6 fatty acid families were generally higher in muscles of Group E and Se than in control. However, in loin, no significant differences were observed between control and Se group for C 22:5 *n*-3 and C 22:6 *n*-3 and in brisket for C 22:5 *n*-3. The lack of difference might occur due to biohydrogenation of docosahexaenoic acid (C 22:6 *n*-3) converting into behenic acid (C 22:0) in Group Se. At the same time, it seems that including high levels of vitamin E in the diet resulted in higher levels of *n*-3 fatty acids, somehow modifying the long-chain fatty acid synthesis. Besides this, higher levels ($P < 0.05$) of *n*-6 fatty acids were found in vitamin-E- and Se-supplemented groups than in the control group in both muscles.

A previous report (*Depenbusch et al.*, 2008) showed that feeding DDGS appears to alter fatty acid profiles in beef. In our study, the PUFA/SFA ratio was considerably higher in group E and Group Se than that of control group, however, less than the lowest limit recommended for improving human health (0.45). It can be difficult to recommend a ratio when individual fatty acids within groups/families can have decisively different biological effects, namely the *n*-6/*n*-3 ratio did not change favourably in the supplemented group due to greater content of *n*-6 fatty acids. From this point of view, the control group showed a desirable value.

Health index (HI) is a ratio which was calculated directly from the sum of MUFA and PUFA in numerator and C14:0 and C16:0 in denominator; consequently, this greater HI value is beneficial. According to the data, Group E and Group Se had markedly higher health-promoting effects than Group C.

4 Conclusions

Adding a supplement containing vitamin E or Se during the finishing period of Holstein bulls successfully produced greater contents of these desirable components in beef. Vitamin-E or Se-enriched beef made some changes in the fatty

acid composition of beef. It is concluded that PUFA/SFA ratio and Health Index generally enhanced supplementing the diet with vitamin E or selenium in DDGS diet, but higher PUFA/SFA ratio resulted in a less desirable n-6 to n-3 ratio in beef.

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