

PAPER

Influence of stall finishing of Podolian young bulls raised on pasture on fatty acid composition and oxidative status of meat

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Abstract

Sixteen Podolian young bulls were used to study the effects of two different feeding systems on fatty acids composition and oxidative stability of meat: C group, eight young bulls were kept indoors and fed with commercial concentrate for all experimental period (260 days); PC group, eight young bulls were allowed to graze a pasture for 200 days and shifted indoor, fed with concentrate, 60 days before being slaughtered. Meat from young bulls that were allowed, before stall finishing with concentrate, to graze a natural pasture showed lower levels of some *n-6* PUFA and higher levels of some *n-3* PUFA than meat from animals that were offered only concentrate for the whole experimental period. Lipid oxidation was not affected by the dietary treatment. After a period of 60-day-indoor finishing with concentrate, meat retained part of the health benefits, with regard to fatty acid composition, occurring from grazing.

Introduction

Podolian cattle is one of the most important native Italian breeds, traditionally kept on pastures in Southern Italy and well adapted to the difficulty of the area (Marino *et al.*, 2006). Animal husbandry of autochthons breeds, subjected to a lower selective pressure and a higher natural selection, in protected areas can provide an opportunity for sustainable use of natural ecosystems. Consumers preferences are positively influenced from the extensive rearing system used for these animals (Gregory, 2000).

In the last years the consumers' demands in terms of quality are increased. Consumers require meat which is safe, of consistent eating quality, healthy and convenient. Numerous studies (Keys, 1970; Mensink *et al.*, 2003; Gidding *et al.*, 2005) have confirmed that there is a strong relationship between the lipids consumed in the human diet and serum total cholesterol. Different epidemiological studies have been associated the consumption of red meat with the development of cardiovascular disease and colon cancer (Cross *et al.*, 2007; Kontogianni *et al.*, 2008). In particular, fat content and fatty acid (FA) composition have been proposed as possible responsible. Dietary recommendations for humans, promoting the consumption of less saturated fat (WHO, 2003), have led to an increased interest in meats containing more unsaturated FAs. A low intake of saturated fatty acids (SFA), a high intake of polyunsaturated fatty acid (PUFA) and therefore an increased PUFA:SFA ratio has been associated with reduced risk of human coronary heart disease (Ulbricht and Southgate, 1991; Clarke *et al.*, 1997; McAfee *et al.*, 2010).

Ruminant fat has a higher SFA and a lower PUFA than non-ruminant fat, due to hydrogenation of unsaturated FAs in the rumen (French *et al.*, 2000). Different studies have demonstrated that ruminants fed to the pasture show a higher level of *n-3* PUFA in meat than ruminants fed with grain based diets (Enser, 2000; Yang *et al.*, 2002; Scerra *et al.*, 2011). Ruminants grazing pasture may have the ability, through enzymatic activity, to synthesise the long-chain *n-3* FAs, Eicosapentaenoic (EPA) and Docosahexaenoic (DHA), from their precursor α -linolenic acid, although the conversion efficiency is relatively low (Enser *et al.*, 1998; French *et al.*, 2000). Moreover, diets rich in forage favor the growth of fibrolytic microorganisms that are the principal responsible for high hydrogenation activity in the rumen and consequently of conjugated linoleic acid (CLA) and vaccenic acid (C18:1 *trans*-11, precursor of CLA in tissue) productions (Baumann *et al.*, 1999).

Another important aspect in meat is the retention of quality, negatively influenced by oxidation of lipids, mainly PUFA, and mioglobin during storage, responsible for product discards and deterioration of meat colour (Faustman *et al.*, 2010). Many factors interact with meat oxidative stability. One of the most important is the balance between antioxidant and pro-oxidant components (Descalzo and Sancho, 2008). As previously said, dietary strategies based on pasture have been report-

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ed to enhance the concentration of PUFA in muscle, but they also increase the levels of antioxidants with a consequent improvement of meat oxidative stability (Faustman *et al.*, 2010).

Availability of forage for grazing ruminants in the Mediterranean areas changes seasonally, whereas the availability of herbage mass is the lowest in winter. In this context, the possibility of restricting the time spent at pasture, thus reducing grazing pressure, may be of interest; still, such strategies should not damage animals' performances.

The objective of the present experiment was to evaluate the effect of the change from a pasture to a concentrate-based diet on FA profile and oxidative stability of raw meat from Podolian young bulls.

Recently, Alfaia *et al.* (2009) and Yüksel *et al.* (2012) studied the effect of the use of concentrate before slaughter, in young bulls raised to the pasture, on meat quality. However, there are some differences with our experiment. In the trial of Yüksel *et al.* (2012) the bulls were transferred in a feedlot and fed with concentrate 40 days before being slaughtered (in our trial 60 days before slaughtering), whereas in the experiment of Alfaia *et al.* (2009) the animals were slaughtered at different times and therefore at different ages (in our experiment all the bulls were slaughtered at the same age). Moreover, considering the importance that Podolian breed holds in supporting of socio-economic development of marginal areas such as the South of Italy, we wanted to verify the effect of this strategy on meat quality of this native breed.

Materials and methods

Experimental design, animals and diets

The experiment, which lasted 260 days, was carried out from June 2012 to March 2013 in a farm located in Calabria (Italy, 38°38' N, 16°04' E). Sixteen Podolian young bulls born between April and June of 2011 were used. The herd was maintained in extensive conditions grazing on spontaneous pastures, summer wheat and corn stubbles. After weaning, with mean body weight of 230 kg±25.58 SD (aged 405±31.27 days), the bulls were divided into two groups, with eight bulls each, according to body weight. Treatments included: indoor with concentrate (C), where the Podolian young bulls were kept indoors, in individual boxes, and fed with commercial concentrate (2.80% live body weight) for all the experimental period (260 days); pasture and concentrate (PC), where the animals were allowed to graze a natural pasture for 200 days and, 60 days before being slaughtered, they were fed with concentrate offered indoors. During the fattening period, PC bulls received the same concentrate and at the same level as C bulls. The chemical compositions of feed offered are presented in Table 1.

The animals were gradually adapted to the experimental diets during the first 10 days from the separation into groups.

During feeding indoor with concentrate, the animals received a small straw integration and water was available *ad libitum*. The concentrate and straw amounted, respectively, to 85 and 15% of the diet on a fed basis.

The botanical composition of the pasture consisted predominantly of Gramineae (80% approximately, *Dactylis glomerata* L., *Hordeum murinum* L., *Avena sterilis*), and a smaller extent of Leguminosae (20% approximately, mainly *Onobrychis saxatilis* L.).

All the animals were individually weighed monthly in order to estimate the average daily gain (g/day).

Animals were slaughtered in a commercial abattoir. One hour after slaughter the dressed carcasses were weighed, split into two sides, chilled for 48 h at 1-3°C, and the right side was dissected into different commercial cuts. Samples of *longissimus dorsi* (LD) muscle were vacuum packed in plastic bags and frozen at -25°C until analysis.

Feed analysis and meat proximate analysis

Feed samples were analysed for neutral detergent fibre (NDF) (Van Soest *et al.*, 1991),

crude protein (AOAC, 1995; method 984.13), crude fat (AOAC, 1995; method 920.39), ash (AOAC, 1995; method 942.05) and FA composition [Gray *et al.*, 1967; FAs were expressed as percent of total FAs methyl esters (FAME)].

In muscle samples of LD, moisture (method no. 950.46), crude fat (method no. 991.36), ash (method no. 920.153) and protein (method no. 984.13) were assessed according to AOAC procedures (1995), after 24 h of thawing at 4°C.

Intramuscular fatty acid determination

Total lipids were extracted according to the method used by Folch *et al.* (1957). Briefly, a 5 g of homogenised LD muscle samples were blended with extraction solvent chloroform/methanol (2:1, v/v) twice, filtered, placed in separator funnels and mixed with saline solution (0.88% KCl). After separation in two phases, the aqueous methanol fraction was discarded, whereas the chloroform lipid fraction was washed with distilled water/methanol (1:1, v/v). After a further filtration and evaporation by means of a rotary evaporator, lipid extracts were transferred to test tubes for subsequent gas chromatographic analysis. Duplicates of 100 mg of lipid were methylated by adding 1 mL of hexane and 0.05 mL of 2 N methanolic KOH (IUPAC, 1987). Gas chromatograph analysis was performed on a Varian model CP 3900 instrument equipped with a CP-Sil 88 capillary column (length 100 m, internal diameter 0.25 mm, film thickness 0.25 µm). Operating conditions were: a helium flow rate of 0.7 mL/min, an FID detector at 260°C, a split-splitless injector at 220°C with an injection rate of 120 mL/min, an injection volume of 1 µL. The temperature programme of the column was: 4 min at 140°C and a subsequent increase to 220°C at 4°C/min. Retention time and area of each peak were

computed using the Varian Star 3.4.1. software. The individual FA peaks were identified by comparison of retention times with those of known mixtures of standard FAs (FAME mix 37 components from Supelco Inc., Bellefont, PA, USA) run under the same operating conditions. Fatty acids were expressed as percent of total methylated FAs.

Muscle fatty acid oxidation measurements

Fatty acid oxidation was monitored in minced raw meat by measuring thiobarbituric acid reactive substances (TBARS) at each day of storage (Siu and Draper, 1978). Briefly, 2.5 g of minced LD was homogenised with 12.5 mL of distilled water operating at 9500 g force. Samples were maintained in a water/ice bath during homogenisation. Then, 12.5 mL of 10% (w/v) trichloroacetic acid were added to precipitate proteins and samples were vigorously vortexed. Homogenates were filtered through Whatman No.1 filter paper. In 15-mL screw-cap glass tubes, 4 mL of clear filtrate was mixed with 1 mL of 0.06 M aqueous thiobarbituric acid and samples were incubated in a water bath at 80°C for 90 min. The absorbance of the samples at 532 nm was measured using a Shimadzu double beam spectrophotometer (model UV-1800; Shimadzu, Kyoto, Japan). The assay was calibrated using solutions of known concentrations of TEP (1,1,3,3-tetraethoxypropane) in 5% (w/v) trichloroacetic acid ranging from 5 to 65 nmoles/4 mL. Results were expressed as TBARS values [mg of malonaldehyde (MDA)/kg of meat].

Statistical analysis

Data of intramuscular FAs were analysed according to a complete randomised design by GLM procedure. The statistical model included

Table 1. Chemical composition and fatty acid profile of feed offered.

	Pasture	Concentrate
Chemical composition		
Dry matter, g/kg wet weight	208.5	867.4
Crude protein, g/kg of dry matter	101.8	144.3
Ether extract, g/kg of dry matter	8.9	23.7
Ash, g/kg of dry matter	104.4	22.2
NDF, g/kg of dry matter	471.5	148.1
Main fatty acids, weight % of total fatty acid methyl esters		
C16:0	19.1	20.9
C18:0	1.6	1.6
C18:1 <i>n</i> -9	4.7	21.1
C18:2 <i>n</i> -6	16.1	51.9
C18:3 <i>n</i> 3	57.6	4.8

NDF, neutral detergent fibre.

dietary treatment as main factor and animal as random factor. Results of lipid oxidation (TBARS values) were analysed with a GLM procedure with repeated measures of Minitab software (Minitab Inc., State College, PA, USA). The model included dietary treatment (C vs PC), time (days 0, 7) and their interaction (dietary treatment time) as fixed effects and individual animal as a random effect. Tukey's test was used for comparing mean values.

Results

Chemical composition and fatty acid profile of diets

Chemical composition and FA profile of the feeds is presented in Table 1. The herbage contained lower quantitative of crude protein and higher NDF compared to the commercial concentrate.

Regarding FA composition, the level of palmitic acid (C16:0) was lower in herbage than in commercial concentrate (19.1 vs 20.9% of total FA, respectively for herbage and concentrate), while the level of stearic acid (C18:0) was similar. Moreover, herbage showed a higher level of linolenic acid (18:3 *n*-3, 57.6 vs 4.8% of total FA, respectively for herbage and concentrate) and lower levels of oleic (C18:1 *cis*-9, 4.7 vs 21.1% of total FA, respectively for herbage and concentrate) and linoleic acids (C18:2 *n*-6; 16.1 vs 51.9% of total FA, respectively for herbage and concentrate) than concentrate.

Performances *in vivo* and meat proximate analyses

Performances *in vivo* and meat proximate analysis are presented in Table 2. No significant difference was found for average daily gain between treatments. As for meat proximate analyses, there were no significant differences between treatments for crude protein, moisture and ash. Only crude fat showed significant differences, where the proportion was higher (P<0.05) in meat from C group (2.49 vs 1.65, respectively for C and PC groups) than meat from PC group.

Intramuscular fatty acid composition and lipid oxidation

The treatments had different effects on concentration of some fatty acids of intramuscular LD fat (Table 3). Among saturated FAs, strong differences were observed in C16:0 and C18:0 proportions. The level of palmitic acid was

higher (P<0.01) in C than in PC group, while stearic acid was present in higher level (P<0.01) in animals that were allowed, before stall finishing with concentrate, to graze a natural pasture. A significantly higher proportion (P<0.05) of total saturated fatty acids (SFA) was observed in the PC group.

Significant difference between treatments was also found in monounsaturated fatty acids (MUFA), being higher (P<0.01) in meat from C group than in meat from PC group. Among MUFA, oleic acid showed the highest level (P<0.05) in meat from animals of C group.

The proportion of the essential FA C18:2 *n*-6 was higher (P<0.01) in C group compared to PC group, while C18:3 *n*-3 showed a higher percentage (P<0.05) in meat from animals of PC group than in meat from animals that were offered only concentrate for all the experimental period. As regard the most present conjugated isomer of linoleic acid (CLA), rumenic acid (C18:2 *cis*-9 *trans*-11) showed the highest level (P<0.05) in meat from PC group. Among *n*-6 FAs, the level of arachidonic acid (C20:4 *n*-6) was higher (P<0.01) in C group than in PC group. Besides linolenic acid, also the levels of other important PUFA of *n*-3 family, as C20:5 *n*-3 and C22:6 *n*-3, were higher (P<0.01 and P<0.05 respectively) in meat from animals that were allowed to graze a natural pasture than in meat from animal of C group. Significant effect of treatments was observed for total *n*-3 PUFA, with higher (P<0.01) values in PC group than in C group, while the level of total *n*-6 PUFA was significantly lower (P<0.01) in PC group compared to C group. According to the effect of treatments on both total *n*-6 and *n*-3 PUFA, the ratio of $\sum n-6/\sum n-3$ PUFA was lowest for PC group (P<0.01).

In the study, the TBARS values measured in

raw LD slices over 7 days of refrigerated storage showed an effect of storage on FA oxidation (P<0.01) (Table 4). However, lipid oxidation was not affected by the treatment or by the treatment time interaction, indicating a similar trend of development of FA oxidation.

Discussion

Intramuscular fatty acid composition

The FA composition of LD partially reflected the dietary FA composition. In ruminants, after lipid hydrolysis in the rumen, many unsaturated FAs are hydrogenated or saturated in stearic acid by certain ruminal microorganisms and the rate of this process changes with different microorganisms family, usually higher with fibrolytic microorganisms (Bessa *et al.*, 2007).

No significant difference was found for average daily gain between treatments. Possibly this data can be explained by the fact that we worked with autochthones breeds, well adapted to grazing in the area, and by a compensatory growth during the fattening period with concentrate. Nevertheless, meat from young bulls in C feeding regimen had higher crude fat than meat from animals of PC group (Table 2). In other words, concentrate-based feeding resulted higher in intramuscular fat levels than pasture followed by concentrate finishing. The result is not an unexpected finding since marbling is related to energy concentration in the diet and time on feed (Dannenberger *et al.*, 2006).

The level of saturated palmitic acid, that is thought to be involved in increasing plasma total and LDL cholesterol, enhancing risks for human health (Scollan *et al.*, 2006), was lower

Table 2. Live weight gain and chemical composition of *longissimus dorsi* of Podolian bulls of both treatment groups.

	Treatment		SEM	Significance
	C	PC		
Body weight				
Initial, kg	232.40	229.50	13.20	ns
Final, kg	450.12	439.20	13.90	ns
Average daily gain, kg/d	0.84	0.80	0.12	ns
Meat chemical composition				
Moisture	74.07	75.02	0.01	ns
Crude fat	2.49	1.65	0.04	0.047
Crude protein	23.64	23.52	0.02	ns
Ash	1.29	1.15	0.01	ns

C, group of young bulls fed with concentrate; PC, group of young bulls fed with concentrate at pasture followed by indoors; ns, not significant.

($P < 0.01$) in meat from young bulls that were allowed, before stall finishing with concentrate, to graze a natural pasture compared to the meat from animals that were offered only concentrate for all experimental period.

In agreement with the results obtained from Arousseau et al. (2007) in lambs, meat from animals of PC group showed higher proportion ($P < 0.01$) of stearic acid than meat from animals of C group. However, grazing sometimes fails to increase C18:0 level in ruminant meat (Velasco et al., 2001; Santos-Silva et al., 2002; Vasta et al., 2009).

The level of total SFA was higher ($P < 0.05$) in meat from Podolian young bulls from C group than in meat from animals of PC group.

In our study, the level of MUFA was significantly higher in the intramuscular fat from stall-fed bulls: this was mainly due to higher level of oleic acid (C18:1 *cis*-9) in the intramuscular fat from animals fed concentrate compared to the animals fed pasture followed by concentrate. The difference in oleic acid (C18:1 *cis*-9) content between groups could be attributed to the greater ($P < 0.05$) fatness of bulls of the stall-fed group compared with bulls of the pasture/concentrate-fed group (2.49 vs 1.65, respectively). Usually, oleic acid increases with fatness. This is due to an increase in the activity of the enzyme Δ^9 -desaturase, which synthesises oleic acid from stearic acid (C18:0) (Baumann et al., 1999).

In the rumen, from the biohydrogenation of linoleic and linolenic acids, a large number of *trans* C18:1 and CLA isomers are derived and accumulated in tissues (Harfoot and Hazlewood, 1988). Among these *trans* C18:1, vaccenic acid (C18:1 *trans*-11) normally shows a higher level in grazing animals than in animals raised indoor with concentrate (Arousseau et al., 2007; Scerra et al., 2007; Vasta et al., 2009). Rumenic acid (C18:2 *cis*-9, *trans*-11), is the major geometric and positional isomer of linoleic acid. An increasing interest on CLA is attributed to its potential health benefits such as anticarcinogenic, antiatherogenic, antidiabetic and antiadipogenic effects (Banni et al., 2003). Unfortunately, in our trial *trans* FAs were not completely separated, so what is reported is the coeluted peak of several *trans* 18:1 isomers in which C18:1 *trans*-11 probably predominates. No differences were observed for C18:1 *trans* concentration, probably due to the finishing indoor period with concentrate. Indeed, as stated previously, vaccenic acid, precursor of *cis*-9 *trans*-11 C18:2 in tissues, is the predominant of *trans* C18:1 isomers in grazing animals, but not in animals fed with concentrate. In fact, was observed that when animals were fed with diets rich in con-

centrates and low in fibre the predominant isomer is not *trans*-11 C18:1 but *trans*-10 C18:1, isomer not associated with *cis*-9 *trans*-11 C18:2 (Aldai et al., 2013). We hypothesise that the probable higher amount of *trans*-11 C18:1 isomer in animals of PC group was converted in *cis*-9 *trans*-11 C18:2. In fact the content of this important isomer of CLA, was higher ($P < 0.05$) in meat from animals of PC group than in meat from animals of C group. Santora and colleagues (2000) showed as, in the muscle, vaccenic acid is partially converted to rumenic acid by the action of Δ^9 -desaturase enzyme. Moreover, Griinari et al. (2000) and Sackmann et al. (2003) underline that the great amount of CLA in meat derived from the desaturation of C18:1 *trans*-11 by Δ^9 -desaturase enzyme.

Despite the indoor finishing period of 60

days, the animals of PC group showed the highest level of linolenic acid ($P < 0.05$, 1.55 vs 0.76% of total FA, respectively for PC and C groups) and the lowest level of linoleic acid ($P < 0.01$, 10.07 vs 12.38% of total FA, respectively). As often reported (Nuernberg et al., 2008; Vasta et al., 2009), concentrations of these essential FAs in meat usually show high differences between grazed and concentrate fed ruminants, with lower level of linoleic acid and higher level of linolenic acid in grazed animals than in animals fed concentrate. This is because grass has a higher concentration of linolenic and lower concentration of linoleic acid than concentrate, mainly in young pasture (Chilliard et al., 2001). In our trial the differences between the experimental treatments results strongly depended on the amounts of

Table 3. Fatty acid composition of longissimus dorsi muscle (g/100 g of total fatty acid methyl esters).

	Treatment		SEM	Significance
	C	PC		
C14:0	2.32	2.15	0.056	ns
C14:1 <i>cis</i> -9	0.10	0.04	0.003	ns
C15:0	0.10	0.11	0.009	ns
C15:1	0.16	0.21	0.011	ns
C16:0	23.16	21.09	0.022	0.009
C16:1 <i>cis</i> -9	1.37	1.62	0.052	ns
C17:0	0.19	0.24	0.081	ns
C17:1	0.26	0.19	0.024	ns
C18:0	14.54	18.53	0.572	0.008
C18:1 <i>trans</i> ^o	0.25	0.35	0.076	ns
C18:1 <i>cis</i> -9	22.94	18.91	0.418	0.031
C18:2 <i>trans</i> -9 <i>trans</i> -12	0.19	0.25	0.073	ns
C18:2 <i>cis</i> -9 <i>cis</i> -12	12.38	10.07	0.452	0.007
C18:3 <i>cis</i> -6 <i>cis</i> -9 <i>cis</i> -12	0.15	0.34	0.065	ns
C18:3 <i>cis</i> -9 <i>cis</i> -12 <i>cis</i> -15	0.76	1.55	0.002	0.045
C18:2 <i>cis</i> -9 <i>trans</i> -11	0.89	1.69	0.005	0.041
C20:1 <i>cis</i> -11	0.21	0.11	0.007	ns
C21:0	0.68	0.75	0.022	ns
C20:2 <i>cis</i> -11 <i>cis</i> -14	2.36	2.35	0.091	ns
C20:3 <i>n</i> -6	0.03	0.02	0.003	ns
C20:3 <i>n</i> -3	0.32	0.39	0.039	ns
C20:4 <i>n</i> -6	8.19	7.83	0.351	0.034
C20:5 <i>n</i> -3	0.24	0.93	0.008	0.003
C22:0	0.03	0.05	0.005	ns
C22:6 <i>n</i> -3	0.17	0.97	0.012	0.043
Unknown	8.01	9.26	0.106	ns
\sum SFA	41.02	42.92	0.336	0.049
\sum MUFA	25.29	21.43	0.285	0.045
\sum PUFA	25.68	26.39	0.398	0.065
\sum <i>n</i> -6	23.30	20.86	0.458	0.003
\sum <i>n</i> -3	1.49	3.84	0.145	0.009
<i>n</i> -6/ <i>n</i> -3	15.64	5.43	0.138	0.007

C, group of young bulls fed with concentrate; PC, group of young bulls fed with concentrate at pasture followed by indoors; ns, not significant; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids. ^oTrans fatty acids were not completely separated, so that C18:1 *trans* represents a mixture in which C18:1 *trans* 11 predominates.

Table 4. Effect of the dietary treatment and time of storage on the thiobarbituric acid reactive substances values measured in raw *longissimus dorsi* muscle slices over 7 days under aerobic storage at 4°C.

	Diet		Time of storage, days		SEM	Significance		
	C	PC	0	7		Diet	Time	Treatment x time
TBARS, mg MDA/Kg	1.67	1.71	0.51	2.61	0.082	ns	0.009	ns

C, group of young bulls fed with concentrate; PC, group of young bulls fed with concentrate at pasture followed by indoors; TBARS, thiobarbituric acid reactive substances; MDA, malonaldehyde; ns, not significant.

these FAs of the grass, where the percentage of linolenic acid was higher (57.65 vs 4.87% of total FA, respectively for grass and concentrate) and the percentage of linoleic acid was lower (16.11 vs 51.96% of total FA, respectively) than concentrate. Nevertheless, the differences of linolenic acid found in this trial between treatments were less accentuated when confronted with differences found in other trial where studied the effect of different rearing systems as pasture vs concentrate on ruminants (Realini *et al.*, 2004; Nuernberg *et al.*, 2005; Popova, 2007). The stall finishing period with concentrate before slaughtered attenuated the effect of the previous fresh grass feeding period, although some of the positive effects of extensive system production are still present.

Consequently to the higher level of linolenic acid in meat from grazing young bulls, its derivative PUFA EPA and DHA, which have a wide range of biological effects and which are believed to be beneficial for human health (Bonanome and Grundy, 1998; McAfee *et al.*, 2010), showed higher proportions in intramuscular fat of animals of PC group ($P < 0.01$ and $P < 0.05$, respectively) than C group.

In relation to the higher amount of linolenic, EPA and DHA FAs in meat from PC bulls, the level of total *n-3* FAs was higher ($P < 0.01$) in meat from these animals than in meat from animals of C group. As a consequence, and also considering that the level of total *n-6* FA was higher ($P < 0.01$) in the young bulls that received concentrate, the level of *n-6/n-3* ratio was significantly lower ($P < 0.01$) in PC group than in the other one. Nevertheless, the level of this ratio, in meat from animals that were allowed, before stall finishing, to graze a natural pasture, was higher (5.43) than recommended value (<4) (Department of Health, 1994).

Fatty acid oxidation in raw meat

For ruminants, extensive feeding systems based on pasture generally promote the deposition of highly unsaturated FAs in muscle, but they also provide higher levels of dietary antioxidants compared to diets based on com-

mercial concentrate (Wood and Enser, 1997). For this reason, pasture-based diets confer on the meat a superior oxidative stability compared to diets based on concentrates only (Luciano *et al.*, 2012). In this study, lipid oxidation was not affected by the treatment or by the treatment time interaction, while lipid oxidation increased during the 7 days of storage period ($P < 0.01$) (Table 4). Probably, the final period of stall finishing with concentrate produced a decrease of the concentration of muscle antioxidants. In the present study, unfortunately, it was not possible to measure concentration of antioxidants in muscle. However, despite meat from PC bulls had the higher level of *n-3* PUFA, that are a highly oxidisable substrates, the lipid oxidation (TBARS) was not different from meat from P bulls. Probably, even if the final period with concentrate produced a decrease of the concentration of muscle antioxidants, this concentration still was higher in meat from animals of PC group than in meat from animals of C group.

Conclusions

In conclusion, this study on Podolian young bulls confirms that meat FA composition from animals that are allowed to graze on a pasture before indoor finishing with concentrate retain a part of the health benefits occurring from grazing. In fact, pastures feeding before indoor finishing with concentrate increases the content of CLAs, which have been ascribed some potential health benefits such as anticarcinogenic, antiatherogenic, antidiabetic and antiadipogenic, C18:3*n-3* and of its derivative polyunsaturated FAs C20:5*n-3* and C22:6*n-3*, which are all beneficial for human health. Moreover, pasture feeding reduces *n-6/n-3* ratio. Nevertheless, the finishing period with concentrate does not allow the maintenance of this ratio under the recommended value of 4. About lipid oxidation, no differences are observed between treatments. Therefore, meat from animals allowed to graze on a pasture

before indoor finishing with concentrate, besides retaining part of the benefits occurring from grazing, does not show higher susceptibility to oxidation than meat from animals fed concentrate.

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