Bulgarian Journal of Agricultural Science, 17 (No 5) 2011, 696-703
Agricultural Academy

FATTY ACID COMPOSITION, LEAN COLOR AND DRIP LOSS OF THE DIFFERENT MUSCLES FROM YOUNG HOLSTEIN FRIESIAN BULLS FINISHED ON DIETS CONTAINING VARIED PROPORTIONS OF WET SUGAR BEET PULP AND WHEAT STRAW

S. YUKSEL[1], L. TURGUT[2], M. YANAR[2*], M. AKSU[3], G. KABAN[3] and N. UNLU[1]
[1] *Eastern Anatolian Agricultural Research Institute, 25250, Erzurum, Turkey*
[2] *Ataturk University, Department of Animal Science, College of Agriculture, 25240, Erzurum, Turkey*
[3] *Ataturk University, Department of Food Engineering, College of Agriculture, 25240, Erzurum, Turkey*

Abstract

YUKSEL, S., L. TURGUT, M. YANAR, M. AKSU, G. KABAN and N. UNLU, 2011. Fatty acid composition, lean color and drip loss of the different muscles from young Holstein friesian bulls finished on diets containing varied proportions of wet sugar beet pulp and wheat straw.
Bulg. J. Agric. Sci., 17: 696-703

The main purpose of this work is to determine meat quality attributes in 3 muscles of the Holstein Friesian bulls fed diets containing varied proportions of wet sugar beet pulp (SBP) and wheat straw. The 15 young bulls were divided into three diet groups. The control group was offered a mixture of wheat straw, dry alfalfa hay and dry meadow hay as roughage. The second and third diet groups were fed a similar mixture of roughage partially substituting wheat straw with wet SBP at levels of 4 % and 8% on a dry matter basis, respectively. Percentage of drip loss in control group was higher ($P<0.01$) than these in 4 % SBP and 8 % SBP diet groups (1.8 % vs. 1.6 % and 1.5 %). The lightness (L*) value was significantly ($P<0.01$) decreased from 37.57 to 32.87 as a result of inclusion of SBP into the diets. However, redness (a*), yellowness, Chroma and Hue values significantly were diminished by increasing the amount of SBP in the diet. Fatty acid composition was not significantly influenced by the diets, but amount of C14:1 and C17:0 fatty acids available in longissimus dorsi, gluteus medius and quadriceps muscles were significantly different. In conclusion, the inclusion of SBP into the diet at 8 % level improved percentage of drip loss and did not cause any adverse alteration of the fatty acid composition of the various beef muscles. However, a* and L* values of the beef decreased as a result of increasing amount of SBP in the diets.

Key words: Fatty acids; diets; drip loss; Holstein Friesian; beef quality; muscles; sugar beet pulp
Abbreviations: GM: *Gluteus medius*, LD: *Longissimus dorsi*, ST: *Semitendinosus*, Q: *Quadriceps*, MUFA: Monounsaturated Fatty Acids, PUFA: Polyunsaturated Fatty Acids, SBP: Sugar beet pulp, SFA: Saturated Fatty Acids

E-mail: mtyanar@gmail.com

Introduction

Feeding among the cattle fattening costs is undoubtedly the most important, as it represents about three quarters of the total variable cost of the animal production. As a result of that, beef producers desire to use alternative feed sources (by-products of food industry) in order to increase animal productivity and profitability. Meanwhile they want to keep meat quality high and to satisfy meat consumers. But the composition of diet and level of feeding have significant effects on the muscle characteristics and meat quality traits, and different sensorial attributes of beef (O'Sullivan et al., 2002 and O'Sullivan et al., 2003). The color of the lean and external fat of meat has been shown to be influential on the purchasing ability and visual acceptability by the consumer (Baublits et al., 2003). Moreover, in red meats, consumers relate a bright-red color to freshness, and discriminate against meat that has turned brown.

The sugar beet pulp (SBP) is one of these by-products of sugar industry. The SBP has great importance in beef cattle feeding programs, since it has highly digestible fiber that may encourage the growth of the cellulolytic and hemicellulolytic microorganisms. It also contains relatively high TDN (about 72 %) and could be used as a roughage source in diets ruminant animals (Lardy and Anderson, 2003).

In Turkey, there is prejudice against meat obtained from cattle fed SBP during the fattening period. Most of the consumers consider the meat to have high percentage of dripping loss during the storage in the refrigerator and has undesirable dark color as well as low amount of desirable unsaturated fatty acid. Although nutritional value of the SBP with other forages for ruminant animals was already compared by Cuvelier *et al.* (2006), comparative information about fatty acid composition, beef color parameters such as L^* (lightness), a^* (redness), b^* (yellowness), C^* (chroma) and H^* (hue value), and percentage of drip loss of the meat from the young bulls fed diets containing varied proportions of SBP and wheat straw is not available yet. Therefore, the study was undertaken to determine the influence of the various diets on the percentage of drip loss, lean color and fatty acid composition of the *Longissimus dorsi* (LD), *Gluteus medius* (GM) and Q*uadriceps* (Q) muscles stored for different periods.

Material and Methods

A total of 15 Holstein-Friesian young bulls (18 months old) were used in this study. The bulls were divided into three groups of five animals of similar body weights (317.40±23.17, 323.25±25.91, 317.00±23.17 kg) and fed individually. All groups were offered a diet containing 60 % of commercial concentrate feed and 40 % of roughage (as fed basis). The roughage consisted of dry alfalfa hay, wet SBP, wheat straw and dry meadow hay. The concentrate was made up of barley, maize, wheat, wheat bran, cotton seed meal, sunflower seed meal and salt. While first group (control=C) was receiving only mixture of the dry meadow hay, dry lucerne, wheat straw as roughage, second and third diet groups were fed a mixture of roughage in which SBP at levels of 4 % and 8 % on dry matter basis, respectively, partially substituted wheat straw in the diet (Table 1). Hence, there were three experimental groups (C, 4 % SBP and 8 % SBP) in the study. The animals were adapted to the finishing diet over 2 weeks before the beginning of the study. All animals had *ad libitum* access to the concentrate and mixture of roughage during whole

Table 1

Composition of the roughage mixture with different levels of SBP

Ingredients (dry matter basis)	Dietary treatment		
	Control	4% SBP	8% SBP
Sugar Beet Pulp	-	4	8
Wheat straw	20	16	12
Dry alfalfa	40	40	40
Dry hay	40	40	40

fattening period (150 days).

All bulls were slaughtered at a commercial slaughterhouse. Average slaughter weights of treatment groups were around 500 kg and they ranged from 489.2 kg to 512.5 kg. Meat samples, after at 24 h postmortem, were taken from LD, GM and Q muscles of the carcases. pH measurements were also made by using a pH-meter.

Drip loss analysis was carried out according to the procedure outlined by Honikel (1998). After the meat sample was cut from the carcass and it was immediately weighed. The samples were placed in the netting and then suspended in an inflated watertight nylon bag, ensuring that the sample did not make contact with the bag and sealed. After the storage periods at chill temperatures (4°C), the meat sample are taken out of the bag and dried by a paper towel and weighed again. Then, the same sample was used for further drip loss measurements, e.g. after 3, 6 and 9 days of the storage, but in every case, the initial weight was used as the reference point. Drip loss is expressed as a percentage of the initial weight.

After taking the muscle samples, lean color was measured in duplicate from inside and outside of the meat samples as reported by Honikel (1998). The beef samples were allowed to bloom for 1 h, then, the instrumental color parameters such as L^* (lightness), a^* (redness), b^* (yellowness), C^* (chroma) and H^* (hue value) were measured by using a tristimulus colorimeter. Before each measurement, the colorimeter was standardized. The data obtained from inside and outside of the meat samples were pooled and the combined data concerning lean color parameters were used in the statistical analysis.

For analysis of the fatty acid, intramuscular fat was extracted and analyzed as reported by Aksu and Kaya (2002). Fat (0.15 to 0.20 g) extracted by the ether method from each sample (total of two), was saponified with 5 ml NaOH with methanol in a water bath for 10 min. Before, at this mixture five mL BF3-methanol was added, and the extract was refluxed for 2 min. After adding 5 mL heptane to the mixture, it was boiled again for 1 min. The content of this mixture was transferred into 25 mL volumetric flasks and the volume was adjusted with saturated NaCl to 25 ml. One mL of the heptane phase from upper layer of the volumetric flasks was used to determine the fatty acids composition. Fatty acids were analyzed by gas chromatography with a capillary column (supel covax 10, 60m x 0.25 mm ID), temperature (increasing from 150 ºC to 200 ºC with rate of 5 ºC / min), FID detector (H_2 and dry air) at 260 ºC, helium gas (1 ml / min, 150 kPa) and injection block temperature of 250 ºC.

The data were statistically analyzed by the least squares tecniques by using SPSS statistics software program (SPSS, 2004). A general linear model with fixed effect of diets, muscles and storage periods and their interactions with each other was used to identify the main sources of variation for studied traits in preliminary statistical analysis. The interactions were excluded from final statistical model, since they were not statistically significant. Therefore, the following different mathematical models were designed to determine the effects of factors such as diets, muscles and storage periods on the drip loss, meat color and fatty acid composition of beef from young Holstein Friesian bulls:

$$Y_{ijk} = \mu + a_i + b_j + e_{ijk} \ldots\ldots..$$

for analysis of fatty acid composition,

$$Y_{ijkl} = \mu + a_i + b_j + c_k + e_{ijkl} \ldots\ldots\text{for analysis}$$

of percentage of meat color parameters,

$$Y_{ijlm} = \mu + a_i + b_j + c_l + e_{ijlm} \ldots\ldots\ldots$$

for drip loss,

Where: Y_{ijk} = Fatty acid composition, Y_{ijkl} = Instrumental meat color parameters, Y_{ijlm} = Percentage of drip loss, μ = Overall mean, a_i = Effect of diets (i: 1, 2, 3; l: Control, 2; 4% SBP; 2: 8%

SBP), b_j = Effect of muscles (j: 1, 2, 3; 1: *Longissimus dorsi*, 2: *Gluteus medius,* 3: *Quadriceps*), c_k = Effect of storage periods (k: 1, 2, 3, 4; 1: 1 day, 2: 3 days; 3: 6 days; 4: 9 days), c_l = Effect of storage periods (k: 1, 2, 3; 1: 3 days, 2: 6 days; 3: 9 days), e_{ijk} = Residual.

Duncan's multiple range test was applied for comparison of subclass means when F-tests for main effects were significant (Duncan, 1955).

Results

Drip Loss

Least squares means with standard errors for drip loss are presented in Table 2. The difference among diet groups in terms of percentage of the drip loss was statistically significant (P< 0.01). While the the percentage of drip loss of the beef from animals fed diet containing 8 % of SBP was the lowest, the same value for the meat obtained from bulls in control group was the highest. The percentage of drip loss of 8 % SBP group was 22.8 % less than that of control group.

In this research, drip loss of the meat occured during the storage period was also measured on the third, sixth, and ninth days of post-mortem (Table 1). Percentages of the drip loss obtained in the three storage periods were significantly (P<0.01) different from each other. The highest percentage of drip loss was determined from beef samples stored for 9 days at 4°C temperature, and the value was 3 times greater than that measured in the meat stored for 3 days. However, drip loss differences among the diet groups in three different storage periods were not statistically different.

The effect of muscle type on the drip loss was statistically significant (P< 0.01). While the percentage of the drip loss of the LD muscle was the lowest, the corresponding value of Q muscle was the highest among the muscle groups.

Meat Color

Least squares means with standard errors for instrumental lean color parameters such as lightness (L*), redness (a*), yellowness (b*), color intensity (C*) and hue (H*) values of the meat are presented in Table 3. The meat color parameters were significantly (P<0.01) affected by the diets containing varied proportion of SBP and wheat straw. While amount of SBP in the diet increased L^*, a^*, b^*, C^* and H^* values of the meat samples significantly diminished (Table 3).

The effects of the different muscle types on all color parameters except for L* value were also significant. GM muscle had the highest a^*, b^* and C^* values compared to LD and Q muscles.

The differences among storage periods for the L^* value were significant (P<0.05), while they were highly significant (P<0.01) for a^*, b^*, C^* and H^* values. On the third day of the storage, meat samples seemed to be on their highest levels of lightness. However, the L* value decreased in the following storage days.

Table 2
Least squares means with standard errors for percentage of the drip loss of beef

	Drip loss (%) $\bar{x} \pm s_{\bar{x}}$
Diets	**
Control	1.8±0.07[a]
4 % SBP	1.6±0.07[b]
8 % SBP	1.5±0.07[b]
Muscle types	**
LD[1]	1.4±0.07[b]
GM[2]	1.8±0.07[a]
Q[3]	1.8±0.07[a]
Storage periods	**
3 days	0.7±0.07[c]
6 days	1.6±0.07[b]
9 days	2.7±0.07[a]

*: P< 0.05, **: P< 0.01, NS: Non-significant,
[1]LD: *Longisimus dorsi*, [2]GM: *Gluteus medius*,
[3]Q: *Quadriceps*
[a, b, c]: Means followed by a different letter within a column are statistically different.

Table 3
Least squares means with standard errors for meat color parameters

	L*[1] $\bar{x} \pm s_{\bar{x}}$	a*[2] $\bar{x} \pm s_{\bar{x}}$	b*[3] $\bar{x} \pm s_{\bar{x}}$	C*[4] $\bar{x} \pm s_{\bar{x}}$	H*[5] $\bar{x} \pm s_{\bar{x}}$
Diets	**	**	**	**	**
Control	34.57±0.21[a]	16.82±0.18[a]	3.73±0.14[a]	17.37±0.20[a]	11.59±0.39[a]
4 % SBP	33.15±0.21[b]	16.30±0.18[a]	3.20±0.14[b]	16.79±0.20[b]	10.59±0.39[a]
8 % SBP	32.87±0.21[b]	15.18±0.18[b]	2.66±0.14[c]	15.50±0.20[c]	9.28±0.39[b]
Muscle types	NS	**	*	**	*
LD[6]	33.80±0.21	15.62±0.18[b]	3.34±0.14[a]	16.19±0.20[b]	11.19±0.39[a]
GM[7]	33.20±0.21	16.72±0.18[a]	3.38±0.14[a]	17.17±0.20[a]	10.65±0.39[ab]
Q[8]	33.59±0.21	15.96±0.18[b]	2.86±0.14[b]	16.30±0.20[b]	9.62±0.39[c]
Storage periods	*	**	**	**	**
1 day	33.19±0.24[b]	16.10±0.21[b]	3.24±0.16[b]	16.49±0.23[b]	10.24±0.45[b]
3 days	34.12±0.24[a]	17.00±0.21[a]	4.02±0.16[a]	17.71±0.23[a]	12.23±0.45[a]
6 days	33.37±0.24[ab]	15.44±0.21[c]	2.85±0.16[bc]	15.78±0.23[c]	10.08±0.45[b]
9 days	33.45±0.24[ab]	15.87±0.21[bc]	2.67±0.16[c]	16.23±0.23[bc]	9.40±0.45[b]

[1]L*: lightness, [2] a*: redness, [3] b*: yellowness, [4] C*: Chroma (color intensity), [5] *H: hue value,
[6]LD: *Longisimus dorsi*, [7]GM: *Gluteus medius*, [8]Q: *Quadriceps*, *: P< 0.05, **: P< 0.01, NS: Non-significant
[a, b, c]: Means followed by a different letter within a column are statistically different.

A similar trend was also observed with a* value. Beef samples stored for 3 days were observed to be redder than these stored for 1, 6 and 9 days. Similarly, the meat in the third days of the storage period had the highest b*, C* and H* values (Table 3).

Fatty Acids

Least squares means with standard errors for fatty acid compositions of beef from bulls fed diets including different proportions of SBP and wheat straw are presented in Table 4. While the influence of the diet groups on the fatty acids composition was not statistically significant, the differences in the amount of C14:1 and C17:0 fatty acids of LD, GM, and Q muscles were highly significant (P<0.01). The effects of the different diets and muscles on the total amount of the saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) were not statistically significant.

Discussion

In spite of the opinion of the some Turkish meat consumers, findings of the present study revealed that as rate of SBP in the forage portion of the finishing diet increased up to 8 %, percentage of the drip loss of the meat decreased. While minimum drip loss values for LD and Q muscles were obtained from Holstein bulls fed diets containing 8 % SBP. In other words, feeding of bulls with SBP at 8 % level resulted in beneficial effect on declining of the dripping loss of the meat. The lower drip loss of the meat could be caused by the higher pH value of 8 % SBP group (5.75) compared to control group (5.56). As indicated by Lee et al. (2008), a muscle of high ultimate pH has a greater water-holding capacity because of its greater hydration of myofibrillar proteins, and therefore, moisture is bonded more tightly by these proteins.

Types of the muscle had significant effect on

Table 4

Fatty acids composition in diet groups and muscle type

Fatty acids, ng/ul	Diets				Muscle types				$S\bar{x}$
	8 % SBP	4 % SBP	Control	S[4]	LD[1]	GM[2]	Q[3]	S[4]	
C10:0	0.014	0.017	0.016	NS	0.02	0.013	0.014	NS	0.006
C12:0	0.016	0.03	0.034	NS	0.027	0.035	0.019	NS	0.011
C14:0	2.088	2.132	2.348	NS	2.111	2.262	2.195	NS	0.122
C14:1	0.383	0.419	0.377	NS	0.479[a]	0.376[ab]	0.323[b]	*	0.043
C15:0	0.422	0.36	0.388	NS	0.327	0.422	0.421	NS	0.045
C15:1	0.294	0.405	0.34	NS	0.249	0.296	0.494	NS	0.089
C16:0	25.536	24.987	26.393	NS	25.727	25.918	25.272	NS	0.562
C16:1	2.542	2.181	2.565	NS	2.801	2.323	2.164	NS	0.219
C17:0	1.11	1.077	0.986	NS	0.938[b]	1.127[a]	1.109[a]	*	0.055
C17:1	0.565	0.557	0.523	NS	0.557	0.549	0.54	NS	0.053
C18:0	1.87	0.769	1.402	NS	1.996	0.858	1.187	NS	0.394
C18:1ω9t	17.895	16.073	19.117	NS	17.121	17.337	18.628	NS	1.192
C18:1ω9c	37.756	37.222	35.445	NS	35.319	38.14	36.964	NS	1.944
C18:2ω6t	1.042	1.088	1.118	NS	1.051	0.983	1.214	NS	0.127
C18:2ω6c	3.539	2.812	3.519	NS	2.93	3.211	3.729	NS	0.329
C18:3ω3	0.1	0.435	0.092	NS	0.3	0.256	0.07	NS	0.155
C20:4	0.154	0.167	0.09	NS	0.149	0.168	0.094	NS	0.039
C20:1	0.056	0.056	0.042	NS	0.041	0.045	0.068	NS	0.019
C20:2	0.055	0.074	0.066	NS	0.094	0.048	0.054	NS	0.018
C20:3ω3	0.006	0.006	0.001	NS	0.003	0.003	0.006	NS	0.003
C20:3ω6	0.035	0.048	0.026	NS	0.028	0.057	0.025	NS	0.024
C22:0	0.076	0.023	0.06	NS	0.045	0.072	0.043	NS	0.029
C22:1ω9	0.416	0.502	0.523	NS	0.335	0.432	0.674	NS	0.132
C20:5ω3	0.148	0.048	0.211	NS	0.104	0.094	0.21	NS	0.088
C24:1	0.044	0.056	0.178	NS	0.039	0.067	0.172	NS	0.072
SFA[1]	31.13	29.396	31.629	NS	31.191	30.706	30.259	NS	0.889
MUFA[2]	59.952	57.47	58.935	NS	56.766	59.565	60.027	NS	20.656
PUFA[3]	5.079	4.678	5.123	NS	4.659	4.819	5.403	NS	0.369
PUFA/ SFA	0.164	0.161	0.17	NS	0.15	0.162	0.183	NS	0.015
MUFA/ SFA	1.937	1.957	3.103	NS	3.016	1.973	2.008	NS	0.698

[1]SFA: Saturated Fatty Acids, [2]MUFA: Monounsaturated Fatty Acids, [3]PUFA: Poliunsaturated Fatty Acids, * : P< 0.05, NS: Non-significant, [1]LD: *Longisimus dorsi*, [2]GM: *Gluteus medius*, [3]Q: *Quadriceps*, [4] S: Significance

[a, b]: means followed by a different letter within a row are statistically different (P<0.05);

the percentage of drip loss and the lowest dripping loss value was obtained from LD muscle compared with GM and Q muscles. Present results support findings of Grosse et al. (1991) who indicated that water retention of LD was the greater than that of other muscle.

Percentage of drip loss has increased with progressing of the storage period, and the corresponding value after 9-day storage of meat was significantly ($P<0.01$) higher than these in 3 and 6-day storages of the beef. Similar results were also already reported by Moron-Fuenmayor and Zamorano-Garcia (2003), and Destefanis et al. (2005).

Inclusion of SBP into the diet at 4% or 8% levels resulted in meat which had lower lightness, lighter red color and lower yellowness values compared to control group. However, Oury et al. (2009) reported that beet pulp seemed to provide muscles with higher red and yellow indices, but L^* value was not significantly affected by the diets based on either beet pulp or corn silage.

Although muscle type did not have significant influence on meat lightness, redness ($P<0.01$) and yellowness ($P<0.05$) values were significantly affected by the muscles (Table 3). The result could be due to structure of the muscles which may influence meat color as it more or less absorbs or reflects light and allows oxygen to penetrate. Kirchofer et al. (2002) also noted that while the β-fiber type was responsible for red color, α-white fibers were mostly responsible for lightnes of the muscles, and the percent of the types of the fibers changes according to the muscles. The significant influence of the muscles on the luminosity, red index (a^* value) and Chroma also observed by Franco et al. (2008).

L^*, a^* and b^* values of the meat were also significantly influenced by different storage periods. The a^* and b^* values of the meat stored for 9 days at 4ºC were lower than these of meat measured in first day of the storage. The lower a^* and b^* values are probably due to more accumulation of metmyoglobin on the surface of the meat during the storage period. Similar results of the present study were already reported by Yadata et al. (2009) who observed a significant change of a^* and b^* values of beef muscles during the cold storage at 4°C for 7 days.

The influence of the diet groups on the fatty acid content of the beef was found not to be significant in the present study (Table 4). The results suggested that the inclusion of SBP into the diet at 8 % level did not cause an adverse alteration of the fatty acid composition of the beef. PUFA, MUFA and SFA levels of the meat samples obtained from different diet groups were also not significantly different. Similarly, Cuvelier et al. (2006) stated that there was no significant effect of diets based either SBP or barley on the fatty acid content of the beef except on the ratio C18:2n-6/C18:3n-3 and on the ratio n-6/n-3. On the other hand, results of a study conducted on the sheep' meat by Oflaz et al. (2005) reported that the feeding of sheep with diets having 60 % SBP increased the palmitic ($P<0.05$) and linoleic ($P<0.01$) acid and decreased ($P<0.01$) stearic, oleic and arachidonic acid contents compared with control group. In the present study, the current rates of inclusion of SBP in the finishing diets offered to the bulls were probably insufficient to show any dietary effect on the fatty acid content of the meat.

Significant influence of the muscles on the amount of some fatty acid were determined in the present study, however, the muscles did not have significant effects on the total amount of SFA, MUFA and PUFA. Similarly, Talpur et al. (2007) reported insignificant effects of the muscles on the amount of total fatty acids, SFA and MUFA values in Kundi steers. Alfaia et al. (2007) also reported that the LD muscle, relative to the *Semitendinosus* (ST) muscle, had greater relative proportions of C12:0 and C18:0, and lower values of C8:0, C16:1c9 and C18:1c11. Ribeye portion of LD muscle contain relatively higher ($P>0.05$) amount of trans fatty acids (3.37 %) as compared with distal region of ST muscle (2.84 %). These differences between muscles probably results from

different percentages in muscle fibres (Wood et al., 2004).

Conclusion

The overall results of this research suggested that the inclusion of SBP into the diet at 8 % level improved percentage of drip loss and did not cause any adverse alteration of the fatty acid composition of the beef muscles. However, the redness and lightness value of the meat was decreased as a result of increasing amount of SBP in the diets.

References

Aksu, M. I. and M. Kaya, 2002. Effect of Commercial Starter Cultures on the Fatty Acid Composition of Pastirma (Turkish Dry Meat Product). *J. Food Sci.,* **67**: 2342-2345.

Baublits, R. T., Jr. A. H. Brown, F. W. Pohlman, Z. B. Johnson, D. O. Onks, H. D. Loveday, R. E. Morrow, B. A. Sandelim, W. K. Coblentz, C. J. Richards and R. B. Pugh, 2004. Carcass and color characteristics of three biological types of cattle grazing cool-season forages supplemented with soyhulls. *Meat Sci.,* **68**: 297-303.

Alfaia, C. P. M., M. L. F. Castro, S. I. V. Martins, A. P. V. Portugal, S. P. A. Alves, C. M. G. A. Fontes, R. J. B. Bessa and J. A. M. Prates, 2007. Influence of slaughter season and muscle type on fatty acid composition, conjugated linoleic acid isomeric distribution and nutritional quality of intramuscular fat in Arouquesa-PDO veal. *Meat Sci*., **76**: 787–795.

Cuvelier, C., A. Clinquart, J. F. Hocquette, J. F. Cabaraux, I. Dufrasne, L. Istasse and J. L. Hornick, 2006. Comparison of composition and quality traits of meat from young finishing bulls from Belgian Blue, Limousin and Aberdeen Angus breeds. *Meat Sci*., **74**: 522-531.

Destefanis, G., A. Brugiapaglia, M. T. Barge and P. Barge, 2005. Tenderness variation depending on ageing in Piemontese beef. Proceedings of the Scientific Association of Animal Production (ASPA) 16th Congress, Torino, Italy, June 28-30.

Duncan, D. B., 1955. Multiple range and multiple F test. *Biometrics*, **11:** 1-42.

Franco, J., O. Feed, G. Bianchi, G. Garibotto, F. Ballesteros, F. Nan, M. Percovich, M. Piriz and O. Bentancur, 2008. Parametros de calidad de carne en cinco musculos de novillos Holando durante la maduracion post-mortem. II. Evolucion del color durante su almacenamiento. *Agrociencia*, **12**: 69-73.

Grosse, F., K. Ender and C. Jais, 1991. Die Magerfleischqualität von Mastbullen in Abhängigkeit von Genotyp, Schlachtkörpermasse und Muskel. *Archiv für Tierzucht,* **34**: 131-140.

Honikel, K. O., 1998. Reference methods for the assessment of physical characteristics of meat. *Meat Sci.*, **49**: 447-457.

Kirchofer, K. S., C. R. Calkins and B. L. Gwartney, 2002. Fiber-type composition of muscles of the beef chuck and round. *J. Anim Sci.,* **80**: 2872–2878.

Lardy, G. and V. Anderson, 2003. Alternative Feeds for Ruminants. AS-1182, NDSU Extension Service, North Dakota State University, Fargo, North Dakota, USA.

Lee, S. K., S. M. Panjono Kang, Y. S., Park, T. S. Kim and Y. H. Song, 2008. The quality characteristics of *M. Longissimus* from Hanwoo (Korean cattle) with different floor space. *J Muscle Food*, **19:** 302-314.

Moron-Fuenmayor, O. E. and L. Zamorano-Garcia, 2003. Pérdida por goteo en diferentes carnes crudas, Archivos *Latinoamericanos de Produccion Animal,* **11:** 125-127.

Oflaz, M., N. Ocak, G. Erener, M. A. Cam and A. V. Garipoglu, 2005. Growth, carcass and meat characteristics of Karayaka growing rams fed sugar beet pulp partially substituting for grass hay as forage. *Meat Sci.,* **70**: 7-14.

O'Sullivan, A., K. Galvin, A. P. Moloney, D. J. Troy, K. O'Sullivan and J. P. Kerry, 2003. Effect of preslaughter ratios of forages and or concentrates on the composition and quality of retail packaged beef. *Meat Sci.,* **63:** 279–286.

O'Sullivan, A., K. O'Sullivan, K. Galvin, A. P. Moloney, D. J. Troy and J. P. Kerry, 2002. Grass silage versus maize silage effects on retail packaged beef quality. *J. Anim Sci.,* **80:** 1556–1563.

Oury, M., P. Pierret, D. Coulmier and R. Dumont, 2009. Elements de maitrise de la couleur des viandes chez les bovins de race Charolaise. *INRA Prod Anim.,* **22:** 131-140.

SPSS, 2004. SPSS for Windows. Released 13.0 SPSS Inc., Chicago, Illinois, USA.

Talpur, F. N., M. I. Bhanger and M. Y. Khuhawar, 2007. Intramuscular fatty acid profile of Longissimus dorsi and Semitendinosus muscle from Kundi steers fed on pasture with cottonseed cake supplement. *Int. J. Food Sci. Tech.,* **42**: 1007-1011.

Wood, J. D., R. I. Richardson, G. R. Nute, A. V. Fisher, M. M. Campo and P. R. Kasapidou, 2004. Effects of fatty acids on meat quality: A review. *Meat Sci.,* **66**: 21–32.

Yadata, M. A., C. Werner, M. Tibbo, C. B. A. Wollny and M. Wicke, 2009. Assessment of the sensory quality and shelf stability of selected Horro beef muscles in Ethiopia. *Meat Sci.,* **83**: 113-119.

Received January 6, 2011; accepted for printing September, 23, 2011.