Original article

Effect of protein level and slaughter age on carcass traits and meat quality of Bruna Alpine steers

Davide De Marzo, Vito Laudadio, Vincenzo Tufarelli

Department of Precision and Regenerative Medicine and Ionian Area, section of Veterinary Science and Animal Production, University of Bari 'Aldo Moro', Bari, Italy

Abstract. This study aimed to evaluate the effects of dietary protein level on the growth performance, carcass traits and meat quality of Bruna Alpina steers slaughtered at different ages. Animals were weighing approximately 260 kg and were divided equally into two treatment groups. Group A received a Crude Protein deficient diet (8.50 %) wile group B was given adequate crude protein throughout the study (12.20 % crude protein on a dry matter basis). Four cattle from each group were slaughtered at approximately 30 days intervals. Carcasses were yield graded and chilling took place at 3° C and were aged for 21 days at 4 °C. Proximate analysis of Longissimus muscle were determined and separable components of 11th rib were separated. Cattle in group B which had been fed adequate protein were heavier at slaughter than cattle in group A which was fed the protein deficient diet (486.1 versus 442.4 Kg; $p < .05$) and ADG (1.02 versus 0.63 kg/d; $p < .01$). As for proximate composition of LD muscle groups 190 and 150 days were characterized by the lowest protein ($p<.05$), instead LD from group 190 days showed the highest lipid content (6.98%). We concluded that increasing the amount of dietary protein as used in this study tended to improve some carcass quality.

Key words: Cattle, Nutrition, Protein, Carcass, Meat quality.

Introduction

The level of protein diet intake in beef cattle may influencing carcass and meat characteristics.

Diet leads also to alterations in meat quality traits and nutrients, because biological characteristics of muscular tissue can be affected by diet changes (1).

It has been shown that diet is one of the most important factors influencing carcass yield, cutability and meat qualities of many species (2).

The AFRC (3) and NRC (4) nutritional systems is energy feeding systems for beef cattle currently adopted around the world.

Nevertheless, animal requirements and nutrient utilization vary with breed, feed, management practices and environmental conditions (5).

New smart technologies have begun to permit serious study of this approach, and as technology costs decrease, these smart technologies will allow implementation of precision feeding for individuals on an industry-wide scale (6).

Many works demonstrated that a high plane of nutrition in cattle promoted earlier fattening while a low plane resulted in delayed or slower fattening (7).

High protein diets result in more rapid growth and better carcass characteristics in relation to higher dressing percentages and more fat (8).

Beside this, the beef cattle incorporate genetic gains, as improvement on the feed efficiency and rate of gain, that could have modified their nutritional requirements (9).

The aim of this work was to evaluate the effect of two dietary protein level on performance, carcass traits

and meat quality of Bruna Alpine steers slaughtered at different ages.

Material and methods

Forty Bruna Alpina beef steers were used in this study. Initial live weights ranged from 260 kg to 290 kg. These cattle were randomly divided equally into two groups. One group (A) received a diet in restricted amount of protein (8.50 % crude protein on a dry matter basis), while the second group (B) received and adequate protein amount (12.20% crude protein on a dry matter basis).

Soybean meal was used as the source of supplemental protein. Both diets were calculated to meet requirements for calcium, phosphorous, potassium and vitamin A.

Carcass traits and chemical analysis of longissimus muscle

The animals were slaughtered and dressed conventionally at about forty days intervals in groups of eight (4 animals from each group at specific times).

The slaughtered times was 1: 30 days from trial's start; 2: 70 days from trial's start; 3: 110 days from trial's start; 4: 150 days from trial's start and 5: 190 days from trial's start.

Carcasses were held at 4°C and aged for two weeks.

For proximate chemical analysis of *Longissimus* muscle were used the AOAC procedures (10).

This procedure to measure moisture and protein, contents of Longissimus raw samples.

Total lipids were extracted from the homogenized samples (100 g) using the chloroform/methanol method by Folch et al. (11).

Carcass evaluation

After chilling for 24 hours at 4°C carcasses were ribbed at the 12th rib and evaluated for yield grade using appropriate carcass factors of carcass weight and ribeye area.

Statistical analysis

The data were analyzed using the statistical analysis system Proc Mixed of SAS (12). The general linear model and least square means procedures were used. Test for variables such as slaughter time, treatment, post-mortem time, used the normal residual error term. The Duncan's new multiple range test (DMRT) by Snedecor and Cochran (13) using the statistical analysis system was used to test for differences among treatment mean.

Results and discussion

Our main objective was to evaluate the impact of dietary protein concentration on production parameters, carcass traits and meat quality of growing Bruna Alpina steers. The literature, in regard to the effect of the reduction of the protein level of diet on the performances of beef cattle in the finishing phase, is not very consistent, and sometimes, shows opposite results (14, 15, 16). This is likely due to the fact that the optimal protein level for a finishing animal depends on many factors, among which there are breed, live weight, ADG, housing conditions and energy. However, as reported in different studies (17), an excess of protein required by the animals could have negative effects for the environment, since most of the protein in excess is excreted as NH_3 in urine and feces. In Table 1 are reported the in vivo performance of the animals feed by different dietary protein level and slaughtered at different time. Initial live weight was similar within each slaughter age ($p > .05$). The higher protein level (12,20%) resulted in greater growth of the animals with a better final weight even if in the period from 30 to 150 it was not significant ($p > .05$); while, the administration of the diet with the highest protein content (12.20%) produced a better total gain (+ 9.9%; $p < .05$) and consequently a higher final live weight ($p < .05$) in animals fed until 190 days. Similar results were reported for the performance of finishing Charolais bulls in the Italian rearing system (17). Moreover, Rusche et al. (18) found a slightly increase in ADG of Angus × Hereford

Table 1. In vivo performance of steers feed by different dietary protein level at different feeding times (means ± se)

Slaughter time	**1**		**2**		**3**		**4**		**5**	
Diet	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
Days on feed	30	30	70	70	110	110	150	150	190	190
No. Per group	4	4	4	4	4	4	4	4	4	4
Initial live wt, kg.	272.4±11.2	281±4.1	272.6±9.2	266.3±3.5	285.0±14.4	277.2±11.9	260.7±4.3	279.6±9.6	287.2±11.0	289.7±5.9
Final live wt., kg.	291.3±10.5	311.5±7.0	325.5±3.1	331.2±11.8	355.1±11.9	365.3±21.5	396.2±16.1	422.6±12.3	442.4±17.7b	486.1±0.7a
Total gain. kg.	18.9±1.1	30.5±5.2	42.9±7	64.9±11.3	70.1±6.7	88.1±4	136.5±10.8	143±6.1	155.2±9.5b	196.4±11.3a
ADG, kg.	0.63±.3	1.02±.1	0.61±.1.4	0.93±.2.8	0.64±.1.1	0.80±.03	0.91±.1.5	0.95±.2	0.81±.1.1	1.03±.1.1

1, 2, 3, 4, 5: respectively 30, 70, 110, 150 and 190 days from trial's start.
A: 8.50 % crude protein on a dry matter basis; B: 12,20 % crude protein on a dry matter basis. ADG: Average daily gain.
a, b.: Horizontal means on the same line within the same slaughter time bearing different superscripts differ significantly ($p<0.5$).

cows with the increase CP. In a study conducted by Dal Maso et al. (19), reducing dietary CP concentration from 14.7% to 11.0% resulted in no variation in ADG, DMI or final weight in double-muscled Piemontese cattle. On the contrary, in Gleghorn et al (14) feeding three different CP levels (11.5%, 13.0% and 14.5%) to British x Continental steers found the highest performance with 13% of CP. Furthermore, it was found that DMI differed only in the first 84 d of the trial. The findings of this study show a greater growth gap between the two diets especially in the early stages of growth (from 30 to 70 days). This trend agrees with Prior et al. (20) who reported that dietary protein had a significant effect on average daily gain within the first 21 days of the experiment when the average initial weight was 275 kg. It therefore can be assumed that plane of nutrition and perhaps other treatments can dramatically affect growth in early post-natal. The daily gain obtained in the present study, although not extremely high, was similar to those reported by Trenkle (15) who in implanted continental crossbreed steers, animals fed 14% CP from the 90 d to the 112 d of the finishing period gained 9.9% more and had a higher DMI than implanted steers fed 11% CP. This difference in growth can be due a true gain in muscle weight most probably was due to a true gain in muscle weight i.e., protein accretion rather than fat deposition since the data showed no significant difference in fat thickness at the 12th rib until cattle were on feed for 150 days. Although we cannot confirm this hypothesis because muscle protein turnover was not determined, the data indicated that animal growth is influenced by dietary protein more during the early stages than at the later stages of physiological maturity.

In Table 2 are presented carcass traits of the animals feed by different dietary protein level and slaughtered at different time. The different dietary protein level had no effect on the carcass weight, fat thickness and ribeye area when the animals were subjected to the dietary treatment from 30 to 110 days (p> .05). As a reflection of the greater final weight differences observed between the two protein levels in the 150 and 190 groups, the animals fed with the higher protein diet (12.20%) showed heavier carcasses (p <.05), higher fat thickness and a wider ribeye area (p <.05); while, diet did not affect (p<.05) carcass yield for all treatment times (from 30 to 190 days). The obtained results are in accordance with those reported for Charolais bulls by Cortese et al. (17). However, the results in the present study showed that feeding a reduced protein diet resulted in less (p<.05) fat on cattle that had been fed more than 150 days. More fat has been observed when higher energy diets were fed to beef cattle (21). It is not necessarily expected, however, that nutritional manipulation results in either restriction or stimulation of growth. For instance, Li et al (22) showed differences in live animal weight in yellow cattle when fed a high energy diet.

In Table 3 are reported carcass traits results considering only the effect of the slaughter times (from 30 to 190 days). As expected, the final live weight and carcass weight significantly increased with the slaughter time. Marked differences in carcass weight among all slaughter ages (from 30 to 190 days; p <.05) were found. The highest carcass yield was observed at 190 days (p<.05), while the lowest at 30 days (p<0.05), intermediate carcass yields were registered at 70, 110 and 150 days (p>.05). Fat thickness and ribeye area increased with the age of the animal. Fat thickness and ribeye area increased with the age of the animal. As regards fat thickness significantly differences were found between 190 days and all other feeding ages (P<.05), as well as between range 110-150 compared with 30 -70 days (p<.05). For the ribeye area, the differences were more evident between 30 days compared with 110, 150 and 190 days (p.<05). Nutritional treatment has been reported to influence the relative growth of muscle based on animal age (23). The effect of nutrition on the immediate post-natal period is important in muscle weight distribution. However, in later stages of growth, plane of nutrition (high vs low) would be expected to have little effect on muscle distribution (24). In the present study, longissimus dorsi muscle area increased whereas fat thickness over ribeye area increased twofold when live weight increased. These results agreed with Hedrick et al. (25) who reported a 50% increase in longissimus dorsi area and a twofold increase in subcutaneous fat thickness when steer carcass weight increased from 160 kg to 385 kg. Plane of nutrition has a well-known effect on the fattening pattern. The work of Ha et al (26) with pigs demonstrated that a high plane of nutrition promoted earlier fattening while a low plane resulted in delayed or slower fattening. These

Table 2. Carcass traits of steers feed by different dietary protein level at different feeding times (means ± se)

Slaughter time	**1**		**2**		**3**		**4**		**5**	
Diet	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
Carcass wt., kg.	160.21±8.0	174.4±7.1	192.4±3.4	197.7±7	213.8±10.1	220.3±10.1	237.7±10.3b	257.5±5.2a	269.6±10.2b	296.52±8.9a
Carcass yield%	61.2±1.8	57.6±1.9	57.9±1.2	61.2±1.7	62.3±1.1	61.4±.6.8	57.6±.6.9	61.9±.4.1	63.4±.3.3	62.5±1.1
Fat thickness, cm^2	0.47±.01	.62±.01	0.65±0.3	0.77±.2.6	0.97±.1.1	1.2±.2.6	1.07±.2.1 b	1.61±1.8a	1.33±.1.8b	1.9±.3a
Ribeye area, cm^2	55.3±3.0	56.5±3.9	59.2±2.9	62.1±3.4	64.3±6.1	62.9±1.1	61.1±2.2 b	73.3±0.7a	68.9±4.5	67.1±2.1

1, 2, 3, 4, 5: respectively 30, 70, 110, 150 and 190 days from trial's start.
A: 8.50 % crude protein on a dry matter basis; B 12,20 % crude protein on a dry matter basis.
a, b: Horizontal means on the same line within the same slaughter time bearing different superscripts differ significantly ($p<.05$).

Table 3. Live weight and carcass traits of steers slaughtered at different feeding times (means ± se)

Slaughter time	1	2	3	4	5
Final live wt., kg	301.4±.7c	328.35±6.1bc	360.2±11.6b	409.4±11.2ab	464.25±13.9 a
Carcass wt., kg.	167.3±4.4e	195.05±4.7d	217.05±7.4c	247.6±7.9b	283.06±8.1 a
Carcass yield %	56.4±.6c	59.55±.6b	61.85±.1b	59.75±.55b	62.95±0.1 a
Fat thickness, cm^2	0.54±.6c	0.71±.2c	0.99 ±.2b	1.34 ±.2b	1.60 ±0.2 a
Ribeye area, cm^2	55.9±2.9b	60.65±1.6ab	63.6 ±4.1a	67.2±3.7a	68±0.17 a
Yield grade[f]	1.9±.14c	2.0±.18c	2.6±.3b	3.0±.1ab	3.5±0.3 a

1, 2, 3, 4, 5: respectively 30, 70, 110, 150 and 190 days from trial's start.
a, b, c, d, e: Horizontal means on the same line within the same slaughter time bearing different superscripts differ significantly (p<.05). f: Yield grade estimated using U.S.D.A. equation of loin eye area, fat thickness at 12th rib, % kidney fat, hot carcass wt.

Table 4. Percentage of 9-11 th rib separable edible components and proximate chemical composition of Longissimus muscle (means ± se)

Slaughter time	1	2	3	4	5
	9-11th Rib components edible portion:				
Lean, %	55.06±1.89a	53.81±1.11ab	48.71±1.11 bc	45.17±1.91c	46.21±2.01c
Fat, %	22.31±1.21a	23.8±2.8a	31.12 ±1.02b	38.17±2.92c	39.94±1.55c
Bone, %	17.49±1.13a	15.21±.50ab	14.16 ±.98bc	12.80±.66cd	12.08±.91d
	Proximate composition				
Moisture, %	75.42±.14a	75.10±.22a	74.81±.86a	73.9±1.01a	70.83±.50 b
Protein, %	22.20±.37ab	22.89±.22a	22.60±.28abc	20.55±.75c	21.36±.43c
Ether Extract, %	2.51±.50a	2.56±.61a	3.78±.77ab	4.91±.56b	6.98±.71c

1, 2, 3, 4, 5: respectively 30, 70, 110, 150 and 190 days from trial's start.
a, b, c, d: Horizontal means on the same line bearing different superscripts differ significantly (p<.05).

results have been confirmed in cattle (27). The estimated numerical yield grade was better (P <.05) for the carcasses of the older animals (from 150 to 190 days) compared to the youngest (age range: 30-70), while animals of 110 days showed a higher yield grade value compared with those observed in 30 and 70 days (p<.05). The increase in yield grade relates to a decrease in percent of boneless closely trimmed retail cuts from the round, loin, rib and chuck expressed on a carcass weight basis. In general, these results are in accordance with those reported in other workers (28, 8).

In Table 4 are reported the results of rib separable edible components and proximate chemical composition of Longissimus muscle considering only the effect of the slaughter times (from 30 to 190 days). The separable components of the 9-10-llth rib section were considered important in this study in order to accurately identify compositional differences. Differences were found in separable muscle, fat, and bone at the 9-10-llth rib section between slaughter groups. As animal weight increased, fat deposition within all the fat deposits also increased i.e., fat thickness over the ribeye, percent fat in 9-llth rib, and percent intramuscular fat. In particular, a higher amount of fat was observed in the last two slaughtering groups than in the first two (p<.05), intermediate value was found in the 110 group (p<.05). An opposite trend was found for lean incidence, lower (P < 0.05) in group 150 and 190 days as compared to group 30 and 70 days; similar trend was observed for bone incidence (p<.05). Aberle et al. (29) observed that feeding cattle with high energy diets increased rates of gain as well as the fat content of the carcass.

As for proximate composition of LD muscle, moisture content was lower (P < .05) in cattle after 190 day of feeding trial as compared to other experimental groups. No significant differences were found among the other groups. Furthermore, LD muscles from groups 190 and 150 days were characterized by the lowest protein content as compared to groups 30 and 70 days (p<.05). LD from group 190 days showed the highest lipid content (6.98%) as compared to the other experimental groups with the lowest content for group 30 days (2.51%) and 70 days (2.56%). Cortese et al. (17) found that lowering the protein level from 15% to 13.5% of DM, during the growing and finishing phases in young Charolais bulls, raised according to the Italian system, did not significantly affect the proximate composition. The authors suggested that this lack of difference could be partially due to the very short ageing time (seven days post mortem). It appears that feeding cattle of this type for 190 days was sufficient time to result in a highly marbled muscle. The significant decrease in water content of the muscle after 190 days on feed was highly negatively correlated (r=-.92) with intramuscular fat (r=-.92).

Conclusion

Based on the results, it can be concluded that lowering the protein level from 12.20% to 8.50% of DM, during the growing phase in Bruna Alpina steers does not appear to significantly affect the growth of the animals in the period from 30 to 150 days. Animals fed up to 150 or 190 days with higher protein diet were heavier and showed up heavier carcasses and more fatness. As expected, the final live weight, carcass weight and its characteristics increased with the slaughter time. Separable edible components and proximate chemical composition of Longissimus muscle were also affected by the feeding time. However, more studies are needed to deepen the knowledge on the balance between protein and energy requirements of Bruna Alpina steers during the growing and finishing phases.

Conflicts of interest: The authors declare that there is no conflict of interest in this manuscript.

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Correspondence:
Davide De Marzo, PhD
Department of Precision and Regenerative Medicine and Ionian Area, section of Veterinary Science and Animal Production,
University of Bari 'Aldo Moro', Bari, Italy;
Via Giovanni Amendola, 165/a – Bari 70126 Italy;
Phone: 3201821128
E-mail: davide.demarzo@uniba.it