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The influence of protein levels on growth rate and feed efficiency

T. ČOBIĆ, S. BAČVANSKI and Sofija VUČETIĆ

Faculty of Agriculture,
Livestock Research Institute, Novi Sad (Yugoslavia).

Abstract

With mixed diets crude protein (CP) levels in the dry matter (DM) higher than 13.5 per cent in first fattening period (up to 250 kg), 12.8 per cent in the second (250 - 350 kg) and 12.0 per cent in the final fattening period (350 kg to slaughter) did not significantly affect the performance of bulls gaining about 1 200 g/day. By using high concentrate (HC) diets, CP levels lower than 14.5 per cent in the first period, 13.3 per cent in the second and 12.2 per cent in the final period of fattening significantly affected the LWG of about 1 250 g, but there was no decrease in feed efficiency using some lower CP levels in DM of the ration (12.2 per cent in the first fattening period, 11.1 per cent in the second and 10.0 per cent in the final period). However for the LWG higher than 1 250 g it would be necessary to raise the CP level by one percentage unit. Crude protein levels lower than 10 per cent detrimentally affected the performance of young bulls.

Résumé

Influence du niveau des apports azotés sur la vitesse de croissance et l'efficacité alimentaire

Avec des rations de fourrages et de concentrés, une augmentation de la teneur en matières azotées totales dans la matière sèche au-delà de 13,5 p. 100 en début de période d'engraissement (jusqu'à 250 kg), 12,7 p. 100 en milieu de période (250-350 kg) et 12 p. 100 en fin de période (350 kg - abattage) n'a pas modifié significativement les performances des taurillons ayant un croît de 1 200 g/jour. Avec des rations riches en concentrés, une diminution de la teneur en matières azotées totales en-dessous de 14,5 p. 100 en première période, 13,2 p. 100 en seconde période et 12,2 p. 100 en période finale a modifié significativement le gain de poids autour de 1 250 g/j, mais l'efficacité alimentaire n'a pas diminué sous l'effet de niveaux azotés faibles (12,2 p. 100 en première période, 11,1 p. 100 en seconde et 10 p. 100 en période finale). Cependant, pour atteindre des gains journaliers supérieurs à 1 250 g il faudrait élever le pourcentage de matières azotées totales de 1 point.

Avec des rations ayant une teneur en matières azotées inférieure à 10 p. 100, les performances des taurillons ont été nettement affectées.

Introduction

During the last several years considerable attention has been devoted to the possibility of decreasing protein levels in the rations for fattening cattle. On the basis of extensive research some new feeding standards have been developed (MAFF, 1977 ; NRC, 1970 ; JENTSCH *et al.*, 1975 ; SORENSEN and KOUSGAARD, 1977). However, there is a great variety of breeds and feeding practices used in different parts of the world and therefore the results do not always agree with respect to protein level applied in rations for fattening cattle. In Europe the majority of experiments was conducted with bulls while in the UK and USA they were carried out with steers. However, currently there are more experiments with bulls in these countries too.

This paper deals with some work conducted with the aim of decreasing the protein levels of the rations for fattening young bulls.

Different protein quantities in fattening bulls on mixed rations

Experimental

The experiment was conducted with four groups of nine bulls each (7 Dutch Friesian breed and 2 Simmental x Dutch Friesian crosses). The animals were tied and group fed twice a day. Concentrates were given at the rate of 1.75 kg/100 kg liveweight of bulls, lucerne hay 1 kg and maize silage 7 - 12 kg/head/day. The ratio of concentrates to roughages was about 60 : 40. Fattening period was divided into three periods according to liveweights (LW) of animals (up to 250 kg, 250 - 350 kg and 350 kg to slaughter weights). The feeding scheme anticipated four protein levels in relation to requirements (70, 80, 90 and 100 per cent for the respective groups, I - IV). Therefore in the first period (195 - 250 kg) the amount of DCP per one starch unit (SU) ranged from 140 - 200 g, in the second period (250 - 350 kg) from 126 - 180 g, and in the third period (350 - 435 kg) from 111 to 160 kg. In each period four concentrate mixtures were used, based largely on ground maize, 89 - 63 per cent, and sunflower oil meal, 8 - 34 per cent, plus 3 per cent minerals and vitamins.

Digestibility trials were conducted on three representative animals from each group for all three periods and the nutritive value of the rations was computed using the digestibility coefficients obtained. Inedible hemp residues were used for bedding.

Results and discussion

The results are presented in Tables 1 and 2.

The higher protein level of the rations increase the liveweight gains (LWG), but the differences were small and insignificant. The same applied with the dressing percentage.

GIARDINI *et al.* (1976, 1976*a*) compared different protein levels, from 8 - 15 per cent in the DM and found significant differences in LWG between the level of 8 per cent and higher levels of protein. However, using the beef animals

TABLE 1

PERFORMANCE OF BULLS FATTENED ON MIXED DIETS BASED ON MAIZE SILAGE AND GROUND MAIZE WITH DIFFERENT PROTEIN LEVEL

Group	I	II	III	IV
CP in the DM	13.5-12.0	14.3-12.1	15.7-13.4	16.3-14.3
Number of animals	9	9	9	9
Initial weight, kg	195.89	194.89	194.89	195.22
Final weight, kg	432.33	436.00	434.27	438.66
Experimental days	200	200	200	200
Average daily LWG, g				
Whole fattening period	1183	1207	1198	1218
195 - 250 kg	1088	1092	1099	1142
150 - 350 kg	1253	1248	1254	1263
350 - 435 kg	1201	1267	1234	1245
Dressing percentage	58.7	58.4	59.1	58.0

differences were not significant. In the studies at ITCF (1977, 1978) with young bulls fed on mixed rations containing CP levels from 10.9 to 15.1 per cent no differences were found with respect to LWG, since there was a slight improvement due to the increased protein level. MARTIN *et al.*, (1979) reported that bulls fed on 11.1 - 15.9 per cent CP in the DM in mixed rations did not significantly differ in LWG for the whole fattening period although they did differ during the first 56 days of experiment. On the basis of these data it seems that the protein level in the DM of the ration for fattening of young bulls could not be decreased below 11 per cent, although MARTIN *et al.* (1978) suggest that continuous levels of dietary protein higher than 11 per cent cannot be justified for beef cattle. However, it must be emphasised that the majority of American experiments were conducted with beef cattle of higher LW at the beginning of fattening and therefore they could not be applied directly to European conditions. Lower levels than 11 per cent CP produced lower gains in all the experiments reported.

Daily DM intake (Table 2) depended on the weight of animals, and the variations in the daily amounts of DM consumed were quite small. Intake of digestible crude protein (DCP) was somewhat lower than anticipated, ranging from 89.9 to 99.4 per cent of the expected level. Therefore the ratio of DCP to SU was also lower, ranging from 139 to 184 g in the first period, 120 - 170 g in the second, and 106 - 159 g in the third period of fattening, which corresponds to 13.5 - 16.3 per cent CP in the DM in the first period (195 - 250 kg) 12.8 - 15.7 per cent CP in the second period (250 - 350 kg) and 12 - 14.4 per cent CP in the final period of fattening (350 - 436 kg). The average apparent digestibility of protein ranged from 55.05 to 68.93 per cent, increasing with the protein level of the ration, irrespective of the fattening period.

TABLE 2

INTAKE AND CONVERSION OF FEEDS AND NUTRIENTS IN YOUNG FATTENING BULLS FED ON MIXED RATIONS*

Group	I	II	III	IV
CP in the DM	13.5-12.0	14.3-12.1	15.7-13.4	16.3-14.3
Daily intake, kg				
DM, kg/100 kg LW				
195 - 250 kg	2.34	2.35	2.33	2.33
250 - 350 kg	2.16	2.18	2.16	2.15
350 - 435 kg	1.92	1.92	1.92	1.90
DCP				
Whole exp. period	0.485	0.551	0.606	0.670
195 - 250 kg	0.466	0.505	0.538	0.581
250 - 350 kg	0.483	0.539	0.610	0.678
350 - 435 kg	0.488	0.584	0.637	0.737
SU				
Whole exp. period	4.02	4.04	3.98	3.96
195 - 250 kg	3.36	3.29	3.20	3.15
250 - 350 kg	3.99	4.06	3.93	3.99
350 - 435 kg	4.58	4.71	4.67	4.62
Daily intake, g/kg $W^{0.75}$				
Whole exp. period				
DCP	8.6	9.7	10.7	11.7
SU	71.3	71.2	70.3	69.4
Feed conversion, kg				
DCP				
Whole exp. period	0.410	0.456	0.506	0.550
195 - 250 kg	0.428	0.462	0.489	0.509
250 - 350 kg	0.385	0.432	0.486	0.537
350 - 435 kg	0.406	0.461	0.516	0.592
SU				
Whole exp. period	3.40	3.35	3.32	3.25
195 - 250 kg	3.09	3.01	2.91	2.76
250 - 350 kg	3.18	3.26	3.13	3.16
350 - 435 kg	3.82	3.72	3.78	3.71

* Concentrate to roughage ratio approximately 60 : 40.

Efficiency of DCP decreased by increasing the CP level of the rations, by 11.23 per cent and 34 per cent in groups II, III and IV as related to group I, which indicates a possibility of saving protein, especially in the fattening period after 250 kg of LW.

Our data are in agreement with those of ITCF (1977, 1978) and MARTIN *et al.*, (1978), showing that DM intake and feed conversion were not affected by the level of DCP in the DM of the rations, while GIARDINI *et al.*, (1976, 1976*a*) found a decrease of DM intake and less efficient conversion of feeds at the level of 8 per cent CP in comparison with higher protein levels.

On the basis of these data, satisfactory results in fattening of young bulls on mixed rations have been obtained by providing CP content of DM of 13.5 per cent at the beginning, 12.8 per cent in the middle, and 12 per cent at the end of the fattening period. In this experiment it corresponds to about 8.7, 7.4 and 6.6 per cent DCP in DM. These figures are somewhat higher than those recommended by NRC (1970) ranging between 11.1 and 12.8 per cent of total protein for steers. Our DCP figures concerning protein intake in groups I and II are lower, while those of groups III and IV are higher for the respective LW, than those recommended by JENTSCH *et al.* (1975) for bulls gaining 1 200 g/day.

Different protein quantities in fattening of bulls on high concentrate rations

Experimental

An investigation was conducted with 40 young bulls of the Dutch Friesian breed divided into four groups. The animals were tied and fed individually on HC rations based largely on ground maize, 57.5 - 76.0 per cent, dry sugar beet pulp, 15 per cent, sunflower oil meal 1 - 16.5 per cent and dehydrated lucerne meal 5 per cent, with 3 per cent added minerals and vitamins. In the lowest protein group, corn and cob meal was used at the rate of 32 and 92 per cent instead of ground maize. The animals were fed *ad libitum* and watered from automatic water bowls. In the digestibility studies the same method was applied as described in the previous experiment.

Results and discussion

The results obtained are presented in tables 3 and 4.

The average daily liveweight gains in the first period of fattening ranged from 1,006 g in the animals of group I to 1,370 g in group IV. Liveweight gain of animals fed on rations with 10.0 per cent CP in the DM was significantly lower than with 14.5 and 16.6 per cent CP, while the gain of bulls fed on rations containing 12.2 per cent CP differed significantly from those fed on rations with 16.6 per cent. Although the same tendency persisted throughout the other two periods, the differences between treatments were not significant. However, the LWG achieved in the first period of fattening affected the differences for the whole experimental period (from 136-450 kg) since the LWG were significantly lower in animals of group I, than in those of groups III and IV, and in animals of group II compared with those of group IV. Hence, a CP content lower than 10 per cent in the DM significantly affected the LWG. Our results (OBRAČEVIĆ *et al.*, 1970, 1971, 1975) with higher CP levels in HC rations, ranging from 11.6 to 20.2 per cent CP in the DM, showed no

TABLE 3

PERFORMANCE OF BULLS FED ON HIGH CONCENTRATE RATIONS WITH DIFFERENT PROTEIN LEVEL

Group	I	II	III	IV
CP in the DM	10.0-7.8	12.2-10.0	14.5-12.2	16.6-14.5
Number of animals	10	10	10	10
Initial weight, kg	135.8	136.5	136.2	136.0
Final weight, kg	448.2	448.3	449.3	445.9
Experimental days	288.3	271.0	251.1	238.0
Average daily LWG, g				
Whole fattening period	1084±35^{a}	1150±34^{ab}	1247±45^{bc}	1302±32^{c}
136 - 250 kg	1006±67^{a}	1091±31^{ab}	1215±75^{bc}	1370±70^{c}
250 - 350 kg	1178±38	1192±66	1278±66	1277±34
350 - 450 kg	1086±73	1187±46	1256±57	1251±49
Dressing percentage	58.38	58.58	58.71	59.10

$^{a, b, c}$Means with different superscripts are different.

response in LWG. Similar results were obtained by BUYSSE (1969) by applying 13-17 per cent CP and ITCF (1976*a*, 1977*a*) using rations with 13.2-15.9 per cent CP. However, WILLIAMS *et al.* (1975) found no significant difference in LWG by decreasing the CP level from 14 to 12 per cent versus 12 to 10 per cent. EDWARDS and SWAN (1976) compared two HC rations in fattening bulls and recorded a significant decrease of LWG by decreasing of CP level from 15 to 10 per cent as compared to that from 15 to 14 per cent. At the ITCF (1976) significantly lower gains were recorded by using rations with 12.1-10.3 per cent CP as compared to those with higher CP levels. KAY (1977) obtained considerably lower gains by reduction of protein level from 14.5 to 9.4 per cent or from 12.0 to 9.4 per cent after 250 kg LW of animals. DE BOER and HAMM (1977) concluded that daily gain was unfavourably affected if the amount of protein was lower than 6.5 g of DCP/kg $W^{0.75}$, but the higher protein levels did not affect the daily gains. Our data are in agreement with these, since the amount of DCP/kg $W^{0.75}$ ranged from 5.2 to 3.8 g in group I, 6.6 to 5.2 g in group II, 8.8 to 7.4 g in group III and 11.2 to 9.1 g in group IV, respectively.

Differences in dressing percentage are small and inconclusive as regards the effect of different treatments.

Dry matter intake (table 4) was lower on the low protein ration (group I) in the first and third fattening period. The corresponding figures per $W^{0.75}$ ranged mostly between 80 and 90 g, while only in the last period of fattening the bulls of groups I and II, fed on low protein rations, consumed less than 80 g DM/kg $W^{0.75}$. Data on digestibility of protein ranged between 62.1 per cent, in animals fed on rations with 7.8 per cent CP in the DM, to 76.6 per cent in those fed on rations containing 16.6 per cent CP, which confirmed our earlier observation that the apparent digestibility of protein increased with increasing protein level (OBRAČEVIĆ

TABLE 4

INTAKE AND CONVERSION OF FEEDS AND NUTRIENTS IN YOUNG FATTENING BULLS FED ON HIGH CONCENTRATE RATIONS

Group	I	II	III	IV
CP in the DM	10.0-7.8	12.2-10.0	14.5-12.2	16.6-14.5
Daily intake, kg				
DM/100 kg LW				
136 - 250 kg	2.18	2.19	2.22	2.36
250 - 350 kg	2.17	2.00	2.03	2.14
350 - 450 kg	1.73	1.78	1.91	1.95
DCP				
136 - 250 kg	0.267	0.344	0.460	0.582
250 - 350 kg	0.386	0.440	0.587	0.745
350 - 450 kg	0.338	0.470	0.666	0.816
SU				
136 - 250 kg	3.02	2.99	3.19	3.33
250 - 350 kg	4.61	4.51	4.35	4.54
350 - 450 kg	5.05	5.34	5.58	5.50
Feed conversion, kg				
SU				
136 - 250 kg	3.01	2.74	2.63	2.43
250 - 350 kg	3.92	3.78	3.40	3.55
350 - 450 kg	4.64	4.49	4.44	4.40
Conc. mixture				
136 - 250 kg	4.73 ± 0.20^{a}	4.43 ± 0.18^{ab}	4.06 ± 0.22^{bc}	3.79 ± 0.14^{c}
250 - 350 kg	6.34±0.22	5.78±0.32	5.45±0.28	5.74±0.27
350 - 450 kg	7.37±0.46	6.81±0.25	6.92±0.18	7.05±0.37
136 - 450 kg	6.07 ± 0.17^{a}	5.58 ± 0.15^{b}	5.56 ± 0.10^{b}	5.40 ± 0.09^{b}

a, b, c Means with different superscripts are different.

et al., 1970, 1971). The DCP intake in this experiment is consistently below ROSTOCK's recommendations in groups I and II (JENTSCH *et al.*, 1975). It met these recommendations in group III, and exceeded them in group IV, for the respective LW and LWG. The DCP intake of animals fed 14.5-12.2 per cent CP is close to NRC (1970) recommendations for steers weighing 250-400 kg and gaining 1.3 kg/day.

The feed conversion was most efficient in group IV, with the highest CP level in the DM of the ration. It gradually decreased by decreasing the protein

level, but only significant difference was that between group I (10 - 7.8 per cent CP) and the other three groups, which shows no benefit by feeding rations with a protein content less than 10 per cent, especially at the beginning of fattening, where it should be at least 12 per cent.

BUYSSE (1969), OBRAČEVIĆ *et al.* (1970, 1971, 1975) and ITCF (1976*a*, 1977*a*) found no significant differences in feed intake or feed conversion in bulls fattened on HC rations with higher CP levels in the DM ranging from 11.6 to 20.2 per cent. WILLIAMS *et al.* (1975) reported no difference in feed efficiency of bulls fed on rations containing 11 and 10 per cent, CP in the final period of fattening but another ITCF(1976) report showed a detrimental effect of rations containing 12.1 - 10.3 per cent CP. EDWARDS *et al.* (1976) found significant differences in DM intake and feed conversion efficiency by decreasing CP content of the ration to 10 per cent comparing to 14 per cent of CP, while KAY observed the same tendency (1977) by changing the CP content from 14.5 or 12 per cent to 9.4 per cent. However, DE BOER and HAMM (1977) obtained from MRIJ and FH bulls the LWG of 1 050 - 1 250 g by using the concentrate mixture containing 101 g of CP/kg.

On the basis of these data it seems that for bulls up to 250 kg of LW for satisfactory LWG and feed efficiency the rations should contain at least 14 per cent CP in DM, while about 12 per cent CP would be sufficient up to 350 kg, which could be lowered to 10 per cent in the final period of fattening.

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