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Effect of dietary protein source on net utilization of energy and protein in the carcass of fattening steers

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Abstract

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A comparative study of the net energy and protein utilization of 2 groups of fattening calves from 200 to 407 days of age, which received nitrogen from different sources – urea and sunflower meal, was conducted. Newly introduced indices „Clarc of energy distribution (CED)“ and „Clarc of protein transformation (CPT)“ expressing the transformation along the chain „net energy/intestinally digestible protein in feed – gross energy/crude protein in boneless meat“, were used.

The authors found a lower utilization of net energy for growth (CED = 5.78 against 7.22%), but a higher utilization of protein (CPT = 17.10 against 15.73%) in calves receiving forage protein via urea compared to those receiving it via sunflower meal.

Keywords: Clarc of energy distribution/protein transformation; bulls ‘fattening; sunflower meal; urea

Introduction

The nature/type of the protein supplement in ruminant fattening’ forages affects the microbial activity in the rumen, and hence the efficiency of utilization of energy and protein for maintenance of life and growth (Ganchev et al., 1997; Ganchev et al., 1998). This influence is enhanced when combined with a change in dry matter consumption (Dettle and Preston, 1996; Steen and Kipatrick, 1995; Mathison and Engstrom, 1995; Murphy and Loerch, 1994; Djurbinev et al., 2001). The authors indicate changes both in the growth indicators of the animals and in the chemical composition of the muscles.

It is essential to construct mathematical dependencies (formulas, indices) of these changes, which will allow objective prediction of the processes and facilitate the work of specialists in selection and technologies in animal husbandry.

One of the proposed indices to account the tracking the processes of the transformation of nutrients along the “feed – consumable animal products” chain is “Clarc of energy distribution/protein transformation (Penkov and Genchev, 2018), adapted for ruminants by Penkov (2022).

The aim of the present study is to investigate the transformation of energy and protein along the ‘feed–boneless meat’ chain when fattening calves with fully developed foreguts using complete compound feeds containing different protein sources – urea and sunflower meal.

Material and Methods

The calculations are based on an experiment conducted with 2 groups × 11 bulls from the breed Bulgarian-Blackand-White cattle and Bulgarian Brown cattle from 200 to 407 days of age. The initial live weight of the bulls were: 1st group – 245.8 kg, 2nd group – 235.8 kg and the end one – 458.8 and 459.8 kg, respectively. The main protein source in the fodder of 1st group was urea and of the 2nd group – sunflower meal. The whole ration mixture fed to the bulls was in pellet form with diameter of 16 mm. The animals has free access to feed and water.

The composition and nutritional values of the combined fodders are shown in Table 1.

The pre-slaughtered live weight was measured after a 24-hour fasting diet. The carcasses was cooled to 5°C, for 24 hours. The slaughter analysis was done according to the method of Zahariev and Pinkas (1979).

To determine the content of muscle, fat and bone and their proportion in the carcass, a dissection of the 11th rib was performed, initially sawing off the 11th vertebra just at the joints with the 11th and 12th vertebrae. The separation is continued with the knife, the 10th rib being cut by sliding the knife tightly to the 11th rib and the other by sliding it tightly to the 12th rib. The next incision is made along the line tangent to M. *longissimus costarum* perpendicular to the rib. The part thus separated is weighed, after which the muscle, fat and bone are carefully separated and weighed separately.

The morphological composition of the carcass was calculated according to the equations of Hopper (1944).

The content of crude nutritional substances in the fodders and meat was established according the Weende methods (AOAC, 2007).

The gross energy (GE) content in fodders and meat was established using the formula of Schiemann et al. (1971):

$$GE = 0.0366*CF + 0.0242*CP + 0.017*NPE$$

The Clarc's of energy distribution/protein transformation (CED/CPT) were established by the formula Penkov and Genchev (2018):

CED = gross energy obtained in meat/net energy input (fodder)

CPT = crude protein obtained in meat/protein digestible in intestine input (fodder)

The results were processed statistically using "Descriptive statistics" – Microsoft Excel.

Results and Discussion

Comparing the nutritional value of the two feeds (Table 1), it can be seen that the feed containing sunflower meal in its structure provides less net energy for growth and more protein digestible in the intestine. This is due to the fact that the main energy sources (cereal fodder) participate in a smaller percentage ang more amount from the main source of vegetable protein – sunflower meal.

It is known that the most amount of plant protein is deaminated in the foregut by microorganisms and then reaminated in microbial, which is associated with energy losses, while nitrogen supplied by urea is transformed directly into microbial proteins (Todorov et al., 2021).

Provided that animals from both experimental groups received the same amount of feed daily, the difference in net energy intake and digestible protein in the small intestine for the entire fattening period (207 days for both experimental groups), the differences in the intake of energy and protein come from differences in their content per feed unit (Table 2). The group that received feed with a natural protein

Table 1. Composition and nutritional levels of the combined fodder, fed to calves/bulls

Ingredients, g/kg combined fodder	1st group (with urea)	2nd group (with sunflower meal)
Wheat straw	250	250
Maize (grain)	380	360
Barley	332	283
Sunflower meal (with hulls)	–	80
Urea	12	3
Calcium phosphate	10	6
Limestone	5	7
Vitamin-mineral premix	3	3
Nutritional substances in 1 kg fodder		
Dry matter, %	89	89
Net energy for growth (native/dry matter), MJ	6.43/7.23	5.82/6.54
Protein digestive in the intestine (PDI) (native/dry matter), g	72.54/81.50	85.08/95.60
Ca (native/dry matter), g	64.08/72	63.20/71
P (native/dry matter), g	42.70/48	42.70/48

Source: Authors' own elaboration

source consumed 991.24 MJ less net energy for growth and 20,255.77 g more protein digestive in the intestine. It can be expected that the higher net energy content of feed with a synthetic protein source will help to increase the efficiency of the transformation of ammonia nitrogen into microbial protein, and the microbial fraction of the protein will be digestible in the small intestine of the feed containing urea, and will compensate the higher content of protein digestive in intestine (PDI) in the feed with a natural protein component.

Table 3 reflects the main productive outcomes important for the calculation of Clarc(s). Calves from the second group have about 11 kg lower average live mass at the beginning of the experiment and, accordingly, about 5 kg lower pure meat content. Due to the higher growth, there was compensation at the end of the experiment and the final live masses and accumulated boneless meat were almost the same in both groups.

It is important to note that the average amount of boneless meat accumulated was 6 kg more in the second group.

Salami et al. (2020) found that inclusion of slowly degradable urea in the ration improved average daily gain (+92 g/d/head) and feed utilization (+12 g LWG/kg DMI/head) of finishing cattle.

Pinos-Rodríguez et al. (2010) found no difference in dry matter intake, daily gain, feed efficiency and carcass dressing were not affected ($P > 0.05$) when replacing soybean meal as a protein source with slowly degradable urea, in fattening cattle trials. Similar results were obtained by Corte et al. (2018), who found no effect of protein source on final bodyweight, average daily gain, dry matter intake, gain to feed ratio, carcass traits and steer meat quality in cattle fattening trials.

The data from the chemical analyses of the native meat did not show significant differences in the crude protein content – 20.81 vs. 21.15%, but the fat content in the meat of the second group was 1.2% higher compared to the first group, which reflects the content of gross energy (Table 4).

Table 2. Feed intake (kg-native), net energy (MJ) and protein digestible in the intestine (g) for the entire trial period (entrance of the system)

Indexes	1st group (with urea)	2nd group (with sunflower meal)
Duration of the experiment, days	207	207
Feed intake for 1 day, kg (native/dry matter)	7.80/6.94	7.80/6.94
Feed intake for the whole period, kg (native/dry matter)	1614.60/1436.58	1614.60/1436.58
Net energy intake for the whole experimental period, MJ (= kg feed intake*content in 1 kg)	10386.47	9395.23
Protein digestible in the intestine (PDI) intake for the whole experimental period, g	117 081.27	137337.04

Source: Authors' own elaboration

Table 3. Calf growth and boneless meat deposition in the calf carcass during the experiment

Indexes	1st group (with urea)	2nd group (with sunflower meal)
	x±Sx	x±Sx
Initial live weight, kg	245.80±5.60	234.30±3.90
Initial content of meat (without bones) in the calves' carcasses, kg	110.98±3.62	105.45±3.11
Final live weight, kg	458.80±15.98	459.80±16.10
Final content of meat (without bones) in the calves' carcasses, kg	207.16±6.32	207.61±6.24
Accumulated boneless meat during the experimental period, kg	*96.18±2.98*	*102.16±3.14*

Source: Authors' own elaboration

Table 4. Chemical composition and content of gross energy in 1 kg accumulated meat (native)

Indexes	1st group (with urea)	2nd group (with sunflower meal)
Water, %	74.13	73.48
Crude protein, %	20.81	21.15
Crude fats, %	2.83	4.03
Ash, %	1.23	1.04
Non protein extract, %	1.00	0.30
Content of gross energy in 1 kg, MJ	6.24	6.64

Source: Authors' own elaboration

Table 5. Accumulated gross energy (MJ) and crude protein (g) in the carcass' meat during the experiment (exit of the system) and Clarc of energy distribution (CED) and Clarc of protein transformation (CPT)

Indexes	1st group (with urea)	2nd group (with sunflower meal)
	x±Sx	x±Sx
Total accumulated gross energy, MJ	600.16±18.59*	678.34±20.85*
Total accumulated crude protein, g	20015.29±620.14	21606.84±664.11
Clarc of energy distribution (CED)	0.0578 (5.78%)	0.0722 (7.22%)
Clarc of protein transformation (CPT)	0.1710 (17.10%)	0.1573 (15.73%)

Notice: *-* significant by P < 0.05
Source: Authors' own elaboration

Although our data show compatible values with those summarized by Andueza et al. (2017) – about 20-21% crude protein content and 2.5–4% crude fat content, they are also in line with the conclusions of Steen and Kilpatrick (1995), Hicks et al. (1990) and Murphy and Loerch (1994), who reported a reduction in fat in the meat of calves fed urea supplementation.

When comparing the obtained amounts of accumulated boneless meat and the content of gross energy and crude protein in it, it was found that the group receiving sunflower meal showed higher results (Table 5). For gross energy, the values are 678.34±20.85 versus 600.16±18.59 MJ in the group receiving urea as the main source of protein, and for crude protein – 21606.84±664.11 versus 20015.29±620.14 g.

The group receiving sunflower meal distributed energy from the feed about 1.5 percentage units more efficiently compared to the group receiving urea – 7.22% vs. 5.78%, but the opposite trend was observed for protein – 15.73 vs. 17.10%.

The higher value of "Clarc of protein transformation" can be explained by the fact that the feed containing urea has about 14 grams lower levels of protein digestible in the intestine in each kilogram of dry matter – 81.50 against 95.60 g (Table 1). Despite the lower overall meat protein content, nitrogen utilization in the urea group was much more efficient than energy utilization.

According to Smil (2002), the conversion efficiency of energy from feed to edible products is 3:1, and of protein – 4:1, according to Wilkinson (2011) the ratio „energy in concentrated feed: energy in animal products is 6.2:1, and for protein – the ratio is 3:1. Unlike our data, these sources reported ratios of crude protein to crude protein and gross energy to gross energy. Our data are closest to those cited for the protein by Guoyao et al. (2014) found the efficiency for protein gain percentage – 15.73 – 17.10 against 12.1%.

Conclusions

In the applied fattening scheme (from 200 to 407 days of age), the replacement of the main protein source – sunflower meal with urea shows a lower Clarc of energy distribution – 5.78 against 7.22%, but higher Clarc of protein transformation – 17.10 against 15.73%.

The conversion of ammonia from urea into microbial protein requires more energy, but the same obtained from microbial activity has a better amino acid content and therefore accumulates in the animal body with higher efficiency.

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