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Assessment of net energy and protein utilization in fattened calves using the indexes "Clarc of energy distribution/protein transformation"

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Abstract

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The purpose of the study is to present an adapted methodology for calculating the net utilization of energy and protein along the chain "forage – edible meat" in the fattening of calves by using the newly introduced indices "Clarc of energy distribution (CED)" and "Clarc of protein transformation (CPT)". Using data from scientific trials with calves of the Bulgarian Brown Cattle and Bulgarian Black-and-White Cattle breeds, the formulas for the calculations in detail are described, and real data for numerical values are presented.

Based on the results of scientific experiments of 207 days with fattened calves after sucking period (initial live weight 233.50±5.60 and final live weight 454.60±15.90 kg), the following values were established: CED (net energy fodder – gross energy meat) – 0.0569 (5.69%); CPT (protein digestible in the intestine from fodder – crude protein meat) – 0.1380 (13.80%).

The authors recommend introducing the indices as objective criteria in the following aspects: selection, technological, and ecological.

Keywords: calves' fattening; Clarc of energy distribution; Clarc of protein transformation

Introduction

The main factors that determine body composition are the breed and sex of the animal. Beef cattle breeds have a higher muscle content and lower fat content compared to dairy breeds (Albertí et al., 2008; Pfuhl et al., 2007). Cows and heifers are reported to have higher fat content than steers and bulls (Venkata et al., 2015). Carcass composition can be altered by diet (Keogh et al., 2015; McCurdy et al., 2010). Tissue proportions in cattle also change with increasing age and live weight of animals. Therefore, the growth process itself has the most significant influence on the morphological composition of the carcass.

The most accurate estimate of production efficiency is the net transformation of energy and protein from food to the edible parts of animal production, specifically meat without bones, milk, and eggs without shells (Pirgozliev and Rose, 2015). Different types of energy (digestible, metabolizable, and net) are used to measure the nutritional properties of feed. Traditional indicators to account for these transformations until now have been the daily increase and feed conversion ratio (Taj, 2015; Abdelrahman and Aljumaah, 2014; Saleem et al., 2017; Van der Merwe, 2015). Apart from the fact that inedible parts of the animal's body (skin, bones, internal organs) are included in the calculation, the main drawback is the fact that between the input of the eco-technical chain (forage) and the output (meat) the differences in the content of water and real nutrients are not taken into account (Penkov, 2022).

Penkov and Genchev (2018) propose the introduction and standardization of two main indices that objectively take into account these processes: Clarc of energy distribution (CED) and Clarc of protein transformation (CPT). The names "Clarc(s)" have an ecological context and calculate indices of circulation (biological accumulation and dissipation) of chemical elements passing from one level of the trophic chain to another (Dobrovolskiy, 1998; Baykov, 1994).

The article aims to present an adapted methodology for calculating the net utilization of energy and protein along the "forage – edible meat" chain in the fattening of calves, using the newly introduced indices "Clarc of energy distribution (CED)" and "Clarc of protein transformation (CPT)".

Material and Methods

The calculations made are based on an experiment conducted with 11 bulls from the breed Bulgarian-Black-and-White cattle with live weight at the start of the experiment was 233.5 ± 5.6 kg. The bulls were slaughtered at a live weight of 454.6 ± 15.9 kg. 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 fodder are shown in Table 1.

The pre-slaughter live weight was measured after a 24-hour fast. The carcasses were 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 against the 11th rib, and the other by sliding it tightly against 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 to the Weende methods (AOAC, 2007).

The 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 the intestine (fodder)

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

Results and Discussion

The compound feed (Table 1) meets all requirements for fattening during this period (Todorov et al., 2007).

For a 207-day fattening period, the average daily feed consumption was 7.84 kg (6.90 kg dry matter) – Table 2. During the entire fattening period, one calf consumed an av-

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

Ingredients	g/kg combined fodder
Wheat straw	115
Maize (grain)	438
Barley	298
Sunflower meal (with hulls)	120
Calcium phosphate	4
Limestone	11
Vitamin-mineral premix	8
Nutritional substances in 1 kg fodder	
Dry matter, %	88
Net energy for growth (native/dry matter), MJ	6.89/7.83
Protein digestive in the intestine (PDI) (native/dry matter), g	91.01/103.42
Ca (native/dry matter), g	49.10/55.80
P (native/dry matter), g	30.89/35.10

Source: Authors' own elaboration

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)

Duration of the experiment, days	207
Feed intake for 1 day, kg (native/dry matter)	7.84/6.90
Feed intake for the whole period, kg (native/dry matter)	1622.88/1428.30
Net energy intake for the whole experimental period, MJ (= kg feed intake*content in 1 kg)	11 183.59
Protein digestible in the intestine (PDI) intake for the whole experimental period, g	147 698.31

Source: Authors' own elaboration

erage of 1622.88 kg of feed (1428.30 kg dry matter). Based on the amount of feed (Table 2) and the content of net energy for growth (NER) and protein digestible in the intestines (IP) in 1 kg (Table 1), the total intakes for the entire fattening period were 11,183.59 MJ and 147,698.31 g, respectively (entrance of the system).

Table 3 gives the initial and final live weights of the calves, as well as the accumulated boneless meat in the carcass. During the experimental period, an average daily gain of 1,116 g per day was achieved. Özdemir and Yanar (2021); Diler et al. (2016) and Cerdeño et al. (2006) found similar results in fattening bulls.

With a live weight before slaughter of 454.6 kg and a warm carcass weight of 240.0 kg, a slaughter yield of 52.8% was calculated. Cerdeño et al. (2006) found a warm carcass weight of 229.5 kg and a slaughter yield of 54.6% when fattening Brown Swiss steers and slaughtering at a live mass of 400 kg. For Holstein Friesian bulls, Özdemir and Yanar (2021) established the following slaughter parameters: live weight before slaughter, 471 kg; warm carcass weight, 258.6 kg; and a slaughter yield of 53.7%.

Table 4 shows the chemical composition and energy value of an average sample of the boneless meat (native). Based on chemical composition, the calculated gross energy content in 1 kg of native meat was 6.37 MJ.

The meat's chemical composition, as determined by us, shows a content of 25.6% dry matter, 20.42% protein, 3.76% ether extract, and 1.1% ash.

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

Indexes	x±Sx
Initial live weight, kg	233.50±5.60
Initial content of meat (without bones) in the calves' carcasses, kg	105.43±3.18
Final live weight, kg	454.60±15.90
Final content of meat (without bones) in the calves' carcasses, kg	205.26±6.16
Accumulated boneless meat during the experimental period, kg	99.83±3.01

Source: Authors' own elaboration

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

Indexes	
Water, %	74.45
Crude protein, %	20.42
Crude fats, %	3.76
Ash, %	1.10
Non protein extract, %	0.30
Content of gross energy in 1 kg, MJ	6.37

Cerdeño et al. (2006) found 89.8% crude protein, 7.8% ether extract, and 4.2% ash in 1 kg of dry matter of the meat when fattening Brown-Swiss steers. In the chemical analysis of meat from Holstein Friesian bulls, Özdemir and Yanar (2021) found that 1 kg of meat contained: 24.4% dry matter, 20.9% protein, 1.52% ether extract, and 1.08% ash.

Based on the information from Tables 2, 3, and 4, the accumulated gross energy and crude protein in the carcass meat, accumulated over the experiment period (207 days), as well as the coefficients of energy distribution/protein transformation, were calculated (Table 5).

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	x±Sx
Total accumulated gross energy – MJ	635.92±19.17
Total accumulated crude protein – g	20 385.29±614.04
Clarc of energy distribution (CED)	0.0569 (5.69%)
Clarc of protein transformation (CPT)	0.1380 (13.80%)

Source: Authors' own elaboration

For the entire fattening period, the calves deposited in their meat an average of 635.92±19.17 MJ gross energy and 20,385.29±614.04 g crude protein.

The calculated Clarc of energy distribution (CED) is 0.0569 (5.69%), and the Clarc of protein transformation (CPT) is -0.1380 (13.80%).

Although the calves were restricted in their movements, the conversion of net energy from feed to gross energy in the meat was low, most of it being lost as heat increment.

The transformation of digestible protein in the intestine has a higher efficiency (13.80%). However, compared to our other studies with lambs during the lactation period (Vuchkov and Penkov, 2021), it is significantly lower. To a greater extent, this also applies to the energy conversion.

Data on net "Clarc's" energy and protein utilization in calves are not found in the available literature, and in other ruminant species, they are scarce. Penkov and Vuchkov (2020) found the following values for Screw-horned Longhaired suckling goat kids fattened for 90 days: CED – 0.2197 and CPT – 0.6711. In another study, 90-day fattening of suckling Karakachan lambs resulted in CED values of 0.5062 and CPT values of 0.8715 (Vuchkov and Penkov, 2021). The high values are due to the fact that both species of small ruminants were fed with mother's milk *ad libitum* throughout the whole fattening period.

According to Smil (2002), the energy conversion efficiency (% of gross energy of the fodder for bovine) was 3, and the protein conversion efficiency (% of the crude protein) was -4. According to Wilkinson (2011), the "cereal for beef " energy in MJ to MJ consumable energy in animal product is 6.2, and the fodder protein in kg to one kg consumable protein in animal product is 3. Guoyao et al. (2014) found an efficiency of 12.1% for protein gain. In the last three publications, the entrance of the system (concentrate fodder for ruminants) is based on gross energy and crude protein.

Conclusions

With the thus applied fattening scheme (207-day fattening period at an initial live weight of 233.50±5.60 kg), the test calves/bulls showed the following values of net utilization of energy and protein: Clarc of energy distribution (CED) – 0.0569 (5.69%); Clarc of protein transformation (CPT) – 0.1380 (13.80%).

We recommend introducing the "Clarcs" indicators as objective criteria for enriching knowledge of cattle breeding in three key areas: selection, technology, and ecology.

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