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Chapter 6

Protein Supplementation Is Vital for Beef Cattle Fed with Tropical Pasture

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http://dx.doi.org/10.5772/intechopen.79813

Abstract

The production of beef on pasture is one of the potentials of Brazilian agriculture, mainly due to the territorial extension and climatic conditions. Therefore, the production of beef on tropical pastures mainly consists of the use of tropical forages; when correctly handled, forage plants show good productivity and improvement in the nutritive value. Among main factors that affect the performance of beef cattle fed on pastures, the availability and quality of the pasture stand first. In tropical regions, during the dry period of the year, the production of forage as well as its nutritive value is diminished. Hence, it is necessary to use protein supplements as a feed strategy to promote increased intake and improved nutrient utilization efficiency by animals. In view of this, by-products of biodiesel from oilseeds, such as peanuts, cottonseed and sunflower seeds, with high nutritional values can be used as an animal feed alternative to the protein sources commonly used for the formulation of supplements. Protein supplementation contributes to an increase in live weight gain as well as improvement in ruminal microbiota activity and, consequently, potentiates nutrient utilization efficiency in beef cattle fed with tropical pasture.

Keywords: ammonia, beef, biodiesel by-products, crude protein, grasses, supplement

1. Introduction

The production of beef on pasture is one of the potentials of Brazilian agriculture, mainly due to the territorial extension and its soil and climatic conditions, which are favorable for the cultivation and establishment of tropical pastures of high nutritional value offered to feed ruminant

animals. However, in the transition period from the rainy season to the dry season, which marks the seasonality in forage production, the performance of tropical pastures declines in leaf/stem ratio, reduces in crude protein (CP) content and increases in the proportion of dead material which makes them less palatable by animals due to low nutritional value [1].

Thus, in order to fill a gap resulting from the quantitative and qualitative production of tropical forage, supplementation with protein concentrates emerge as the main alternative in the supply of nutrients for the maintenance and maximization of the production of beef cattle in this productive system, which has as feed base, tropical grasses [2].

The potential of utilization of this feed strategy is evident, since animals supplemented with concentrates, regardless of the feeding strategy, demonstrate greater microbial efficiency when compared to the animals fed just pasture [3]. Corroborating with this work, another study was carried out by Batista and colleagues [4] to test whether a protein supplementation of beef cattle fed with tropical low quality pasture improves the efficiency of the use of nitrogen. Finally, concluding that the supplementation with proteins source with a higher proportion of degraded proteins in rumen favors the recycling of nitrogen and promotes increase in the synthesis of the microbial protein.

As a result of the growing world demand for biofuels, the biodiesel production chain uses oilseeds as raw material for the production of by-products and residues that, due to their nutritional value, have potential for use in animal nutrition, being characterized as protein and energy supplements. Thus, with a view to reducing the impact of the seasonality of forage production on pasture-based meat production systems, increasing the quantity and quality of nutrients and, consequently, maximizing the efficiency of their use, the practice of supplementing together with potential using of by-products from the biodiesel industry emerges as a strategy to increase the production of beef cattle to pasture.

2. Production of beef in tropical pasture

In beef cattle improvement, although the frequent use of confined production systems is very evident, pasture systems have been gaining prominence in their use due to lower feed costs and high response in animal performance (e.g., daily average gain and gain per area), resulting in higher profit margins.

The production of beef in tropical pastures consists mainly of the use of tropical forages. When properly managed, forage plants show high productivity, improvement in nutritional value and nutrient digestibility. In this case, the forage potential of tropical grasses on animal response was investigated by Maciel and colleagues [5] using three guandu grass cultivars (Massai, Tamani and Zuri) in the live weight gain of Nellore steers. The results showed that using grazing the average daily weight gain of cattle were 0.716, 0.791 and 0.883 kg/animal/day for grass cultivars Massai, Tamani and Zuri, respectively.

The use of forage plants of tropical climate to compose a system of production of beef cattle occurs mainly due to its productive potential (kg DM/ha) and its anatomical and physiological characteristics, which are determinant in the choice as much as adoption of the type of pasture management.

Tropical forage plants are grouped metabolically under C4, which possess greater advantage in the productive aspect, with morphological, anatomical and physiological characteristics that contribute to greater forage production per unit area compared to those in the temperate which are dominantly C3. Due to this, the characteristic of C4 tropical grasses becomes advantageous for breeding of bovines as it favors animal productivity by unit area, which can also increase the number of animals within the system.

In this context, De Araújo and colleagues [6] evaluated animal performance in a tropical pasture system with or without supplementation. This study showed that the Mombaça grass with 45 cm height at the end of the rainy season retains sufficient forage mass to maintain throughout the dry period, approximately 1.4 AU/ha, and moderate nutritive value (mean 8.1% CP and 55.3% organic matter digestibility in vitro) to promote small gains. In conclusion, the researchers observed that such responses of quantitative and qualitative adaptability in the period of seasonality of production of forage species demonstrate the aptitude of this species for its use in meat production systems in tropical pastures.

When researching on the agronomic and structural characteristics of the Massai grass under grazing of sheep supplemented during the dry season, Fernandes and colleagues [7] verified that forage mass production considered satisfactory for the dry period of the year, regardless of the type of supplementation and grazing cycles.

Another study on the inherent characteristics of the plant (e.g., canopy structure, nutritional value) showed that the performance of the livestock was influenced by the type of grass management [8]. In this case, the pasture of *Panicum maximum* cv. Mombaça, which was managed at a height of 50 cm instead of 30 cm after grazing, resulted in high average daily gain of cattle (795 vs. 590 g/day of live weight) and high animal production per unit area (917 vs. 794 kg/ha of live weight).

According to Hodgson and Maxwell [9], the pasture management factor is related to the balance between animal production, maintenance of the pasture aiming at achieving higher productivity, improvement in nutritional value and consequent increase in the utilization efficiency of the accumulated forage without initiating the processes of senescence.

In an experiment carried out with forage grass *Digitaria umfolozi* submitted to different defoliation frequencies, the importance of pasture management on the productive characteristics and morphogenic and nutritional value was verified. Thus, in this study, it was found that the higher defoliation frequencies positively favored increasing number of leaf blades, stems + sheaths and total DM, characterizing this tropical forage with good potential for animal production [10]. The findings showed that the defoliation frequencies promote the growth of new *Digitaria umfolozi* grass plants with high concentrations of CP in leaf blades and stems + sheaths, indicating the need to identify appropriate management practices to efficiently harness the forage potential.

Production of meat in pasture refers to the dynamics between availability and the efficient use of forage. This is, animal production as a result of processes of soil-plant-animal interaction. Therefore, to achieve success using this production system, it is necessary to understand the importance and how these processes work until production is reached. According to Hodgson [11], animal production in pasture can be structured in three processes: **Growth**, **Utilization** and **Conversion** (**Figure 1**).

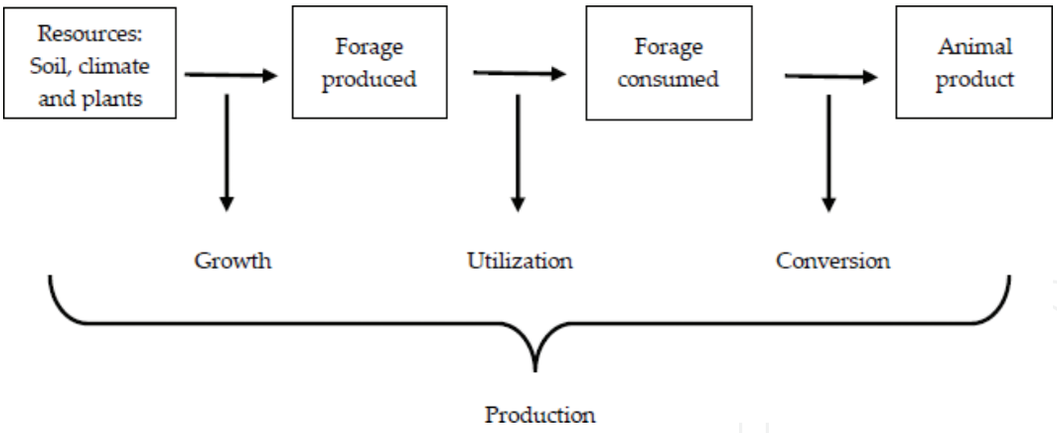

Figure 1. Schematic representation of animal production on pasture. Adapted from Hodgson [11].

At the stage of **growth**, the importance of natural and environmental resources in the development of the plant is observed, where fertile soil corrected for acidity and fertilization, presenting the availability of essential nutrients which together with climatic conditions (e.g., solar radiation, rainfall) favor the growth of the forage plant with greater vigor.

In the next step, which concerns the **utilization**, the forage produced under favorable climatic conditions will be in full qualitative force and available in the production system for the management of the pasture in which it will aim to improve and provide a greater "harvest" of the forage by animals.

Conversion, the last step, is the use of the forage consumed, that is, the ingestion of the forage is related to the efficiency of the use of the nutrients in the transformation to products of animal origin (e.g., beef).

Among major factors affecting the performance of beef cattle fed on pastures, the availability and quality of the pasture stand first. The involvement of meat production in pasture in tropical regions is related to the dry period of the year, in which there is a decrease in forage production and a reduction in nutritive value due to the elongation of the stems, increase in the fibrous fraction and decline in the crude protein of the plant. In this context, the study in the Brazilian savannas carried out by Maciel and colleagues [5] to investigate the effect of Guinean grass pastures on the seasonal live weight gain of beef cattle indicated a reduction in average daily gain (ADG) (0.284 kg/head/day) of Nellore bulls in the dry season. This demonstrates that the seasonality in forage production directly reflects the performance of the animals.

Thus, the use of feed strategies (e.g., concentrated, roughage supplementation) that seek to complement and contribute to the maintenance and increase of meat production in tropical pasture is of great importance for the successful use of the tropical pasture production system.

3. Protein supplementation for beef cattle in tropical pasture

Protein supplementation for beef cattle in tropical pastures is due to the need to supplement the nutrients provided by forage, which is the main source of feed in this production system.

http://dx.doi.org/10.5772/intechopen.79813

Therefore, this feed strategy is necessary, mainly in the seasonality of the forage production, in which the tropical forage plants show a decline in the production, resulting in less availability of forage mass and elongation of the stems, negatively affecting leaf/stem ratio and consequent reduction of nutritional value.

The use of this feeding strategy in grazing livestock systems is an activity that can be applied to pasture management to increase support capacity as well as animal performance [12]. However, the efficiency of the use of protein supplements for beef cattle in pasture systems needs to increase the nutrient intake and to promote the improvement in the efficiency of using scarce resources in order to maximize the production of weight gain by the animals.

The study using different concentrations of protein supplementation on the nutritional and productive performance characteristics of grazing heifers during the rainy, dry and tropical dry seasons carried out by Cabral and colleagues [12] indicated that a maximum gain of 489.4 g/kg body weight was obtained from 1.05 kg of protein supplement, which is equivalent to a 32% increase in average daily gain over those receiving only mineral supplement.

According to Brandão et al. [1], the practice of supplementation of cattle in tropical pastures provides benefits to the ruminal microorganisms since it generates substrates for the development of microorganisms, which in turn improves the digestibility of fibrous feeds and consequently increases the consumption of the forage. Sampaio et al. [13] investigated the consumption and digestibility of beef cattle fed with low-quality tropical forage supplemented with nitrogen compounds. According to their findings, concentrations of 5 and 10 mg/dL of ammoniacal nitrogen provided nitrogen substrates (e.g., ammonia, amino acids) sufficient to maintain the microbial activity in the rumen and improved voluntary intake.

In evaluating the performance and efficiency of nitrogen utilization in cattle fed pasture of tropical grasses with supplementation, Detmann and colleagues [14] showed that nitrogen supplementation enhanced forage intake and nitrogen utilization, which as a consequence improved digestibility. According to this work, the highest benefit of supplementation was observed in the efficiency of nitrogen metabolism in the animal.

The most limiting factor for achieving greater efficiency with protein supplementation is the balance between protein and energy. Protein supplied via supplement is rapidly degraded upon reaching the rumen, hence readily available to microorganisms. Hence, it is necessary to keep the balance between the protein and the energy of the feed.

As a base feed of the pasture system, forage plants when in the rainy season and well managed provide forage of good nutritional value and good digestibility which contribute to a better balance between the protein of the supplement and grass energy. However, in the dry season, tropical forages are markedly affected in the total production and proportion of morphological components (e.g., leaf/stem ratio), in proportion of fibrous fraction, nutritive value, which alters the balance between protein and energy.

Several studies showed the benefits of protein supplementation for beef cattle in tropical pasture systems. However, crude protein concentrations should be adjusted according to the nutritional requirements of the animals. This is important since supplements with high concentrations of crude protein in the diet formulation of animals can generate excess nitrogen

in the animal metabolism which is directed to the liver for urea synthesis and subsequent excretion via feces and urine. Thus, in addition to the energy expenditure in the metabolism and conversion of nitrogen to urea, this metabolite is excreted to the environment causing a negative impact on the natural resources (e.g., groundwater).

Another study Ankole × Friesian crossbred steers carried out by Asizua and colleagues [15] supported the findings indicated above. These studies, therefore, strongly suggested to carefully adjust the amount of fermentative supplements of carbohydrates and proteins and monitor their influence on the dynamics of the ruminal environment.

4. Use of biodiesel by-products in the supplementation of beef cattle in tropical pasture

The use of biodiesel by-products in the supplementation of beef cattle on tropical pasture is an emerging trend within production systems, in which, although tropical pastures are considered as primary source of feed for ruminant animals raised on pasture, the production of animal products (e.g., meat, milk) in these systems today require an increase in the use of agro-industrial by-products and agricultural residues as an alternative way of providing nutrients for economic optimization [15].

In pasture production systems, the supplementation provided for beef cattle is generally formulated with traditional protein sources (e.g., soybean meal). However, by-products resulting from the biodiesel process of oilseeds, such as peanuts, cottonseed and sunflower seeds, have high nutritional values and hence can be used as animal feed as an alternative to the protein and energy sources commonly used in the formulation of supplements.

Table 1 presents the composition of different supplementary sources generated from the biodiesel production chain in terms of dry matter (DM), ash, crude protein (CP) and other key nutritive elements. Neto et al. [16] indicated that using these products instead of conventional ingredients the cost of feeding is saved, without compromising nutritional quality and the efficiency of the beef production.

Based on the study on heifers fed on tropical grass and supplemented with glycerin, Silva and colleagues [17] concluded that the use of biodiesel by-products up to 14.3%, equivalent to 50.5% substitution of the energy, did not alter the centesimal composition of the meat. However, these supplements improved the fatty acid profile of the *longissimus lumborum* muscle and therefore increased the quality of the meat, with benefits for human health.

In response to the effect of replacing soybean meal with cottonseed on supplements containing 15% and 30% CP, as well as evaluating the effect of supplementation on the performance and nutritional status of Nellore heifers, it was evident that supplementation with cottonseed meal containing 30% CP promoted greater DM digestibility when compared to the supplement containing only 15% CP. Based on this, the authors stated that cotton meal can totally replace soybean meal during the rainy season [18].

Nutrients	By-products of biodiesel, g/kg			
	Soybean meal	Groundnut cake	Sunflower cake	Palm kernel cake
Dry matter	958	958	972	966
Ash	59.8	47.5	54.5	55.8
Crude protein	467	44.5	24.3	13.1
Ether extract	22.2	81.2	58.0	112
Neutral detergent fiber	105	143	339	696
Acid detergent fiber	95.0	123	272	401
Non-fibrous carbohydrates	346	283	305	4.60
Hemicellulose	9. 90	20.0	66.4	295
Acid detergent lignin	34.8	56.1	135	289
Total carbohydrates	451	426	644	701

Adapted from Neto et al. [16].

Table 1. Composition of biodiesel by-products used in ruminant animal production systems.

Another study by Trung et al. [19] investigated the effect of different concentrations of cassava root meal supplementation peanut butter on the intake and performance of beef cattle. The study concluded that the combination of 1000 g of cassava root meal with 700 g of peanut cake significantly increased live weight gain with a tendency to improve feed intake and digestibility of organic matter (OM), reducing feed conversion and the cost of the ration.

5. Performance of beef cattle fed tropical pasture supplemented with crude protein

In investigating the use of supplements with different concentrations of crude protein for beef cattle in tropical pasture, Da Silva-Marques et al. [20] found that the supplement with higher crude protein content (601 g/kg of CP based on DM) promoted higher metabolism and efficiency of nitrogen, improving the nutritional parameters of beef cattle during grazing in the rainy season. Another study which evaluated the frequency of protein-energy supplementation and mineral supplementation of Nellore bulls in Marandu grass pasture showed an increase in DM, CP and higher digestibility of CP and NDF of pasture for animals receiving protein-energetic supplement five times a day [21].

Similarly, Neves and colleagues [22] investigated the effect of increasing concentrations of concentrated supplementation on intake, nutrient digestibility and performance of crossbred steers during the dry period of the year. Based on the findings, the authors recommended protein supplementation of 0.5% body weight (BW) with 24% CP to obtain gains of up to 0.500 kg/day for steers in pasture systems during the post-weaning phase in the dry season of the year.

Similar study evaluated the effect of different protein concentrations on performance and metabolism of Nellore cattle in tropical pasture during the transition period from dry season to the rainy season [23]. The results showed that the response to supplementation is related to forage plant characteristics (e.g., forage canopy), resulting in benefits only at the early stage of the transition period from dry to rainy season.

6. Conclusions

Protein supplementation to grasses increases the live weight gain and the ruminal microbiota activity of beef cattle, which consequently potentiating the nutrient utilization in beef cattle fed with tropical pasture. Studies also showed that by-products of biodiesel can be used as alternative sources of protein to improve beef supplementation in tropical regions.

Conflict of interest

The authors declare that there is no conflict of interest.

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