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Original

Animal performance and meat quality in feedlot cattle feeding with different levels of agricultural by-products

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ABSTRACT

Objective. Evaluate the effects of different levels of agricultural by-products concentrate on animal performance and meat quality in feedlot cattle. **Material and methods.** Thirty-Six F1 *Bos taurus x Bos indicus* bulls were used with 347±20 kg of body weight and 18 months average of age on feedlot under tropical dry forest conditions. Experimental treatments were levels of agricultural by-products replacing *Pennisetum sp* grass to 85% forage:15% concentrate (T1); 75% forage:25% concentrate (T2); 65% forage:35% concentrated (T3) and 55% forage:45% concentrate (T4). A completely randomized experimental design was used for evaluation variables as live weight gain (LWG), dry matter intake (DMI), feed efficiency (FE), hot carcass weight (HCW), carcass yield (CY), blood metabolites and fatty acid profile in meat. **Results.** LWG and final weight increased with a higher level of concentrate in the diet ($p<0.043$). There were not differences in blood metabolites. Differences in caproic, caprylic and tridecanoic saturated fatty acids were observed when level of concentrate in diet increased ($p<0.05$) while, in unsaturated and polyunsaturated fatty acids has been not differences between treatments. **Conclusions.** Inclusion of agricultural by-products improved animal performance and three saturated fatty acid decreased in F1 *Bos taurus X Bos indicus* bulls under feedlot in tropical dry forest conditions.

Keywords: Carcass characteristics; supplementation; tropical livestock; tropical dry forest (*Source: CAB*).

RESUMEN

Objetivo. Evaluar los efectos de diferentes niveles de concentrado fabricado con subproductos agrícolas del departamento del Huila - Colombia sobre el rendimiento y calidad de carne en bovinos confinados. **Material y métodos.** Se utilizaron 36 toretes F1 *Bos taurus x Bos indicus* con 347±20 kg de peso corporal y 18 meses de edad confinados bajo condiciones de bosque seco tropical. Los tratamientos experimentales fueron niveles crecientes de concentrado elaborado con subproductos agrícolas en sustitución de pasto *Pennisetum spp* a razón de 85% forraje:15% concentrado (T1); 75% forraje:25% concentrado (T2); 65% forraje:35% concentrado (T3) y 55% forraje:45% concentrado

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(T4). Se utilizó un diseño experimental completamente al azar para evaluar las eventuales diferencias entre variables evaluadas: ganancia de peso vivo (GPV), consumo de materia seca (CMS), conversión alimenticia (CA), peso de la canal caliente (PCC), rendimiento en canal (RC), metabolitos sanguíneos y perfil de ácidos grasos en la carne. **Resultados.** La GPV y el peso final aumentaron con un mayor nivel de concentrado en la dieta ($p<0.05$). No hubo diferencias en los metabolitos sanguíneos. Los ácidos grasos saturados caproico, caprílico y tridecanoico fueron menores cuando el nivel de concentrado en la dieta aumentó ($p<0.05$) mientras que, en los ácidos grasos insaturados y poliinsaturados no hubo diferencias entre los tratamientos. **Conclusiones.** La inclusión de subproductos agrícolas usados en el presente estudio mejora el rendimiento, el consumo de materia seca y reduce el contenido de tres ácidos grasos saturados de la carne en toretes F1 *Bos taurus X Bos indicus* en confinamiento bajo condiciones de bosque seco tropical.

Palabras clave: Bosque seco tropical; características de la canal; ganadería tropical; suplementación (*Fuente: CAB*).

INTRODUCTION

Presently, meat production around the world is being questioned due to its excessive use of resources, generation of greenhouse gases, and its association with the presence of residues such as hormones and antibiotics in meat products (1). Therefore, it is necessary to find a faster, cleaner, and more sustainable production cycles to obtain shorter cycle lengths and maximize performance. Confinement termination systems (feedlots) have been used by some countries, mainly in the United States and Europe (2). The adoption of feedlot systems offers better animal handling, greater administrative control of the system, and controlled feeding. This system maximization allows greater profitability for the producers as it establishes a feed based on animal response, waste avoidance, and offered feed use optimization (3).

The implementation of feedlot systems allows to an increase in yield and meat tenderness. The main limitations are the availability, quality, and cost of feed resources materials, as well as the balanced adequate ratio of forage: concentrate in the diet (4). Evidently, it is necessary to look for finding low-cost raw materials or by-products according to their availability in each region or country and including them in the appropriate proportion in the diets of finished beef cattle, to make these feedlot systems viable. There are several investigations about this challenge throughout the world, but in Colombia studies on the performance and quality of meat in confined cattle with low-cost raw materials are scarce.

The objective of this study was to evaluate the effects of different levels of inclusion of low-cost concentrate in diets for F1 bulls (*Bos taurus* x *Bos indicus*) confined under conditions of tropical dry forest in Tello Huila - Colombia.

MATERIALS AND METHODS

Location. This study was carried out at Hacienda La Paz, municipality of Tello (Huila - Colombia), between the geographical coordinates 3° 4'17.66 "N and -75° 8'38.09" W. The property has bioclimatic characteristics with an altitude of 575 MASL an average temperature of 26.4°C, relative humidity of 71%, and precipitation of 1300 mm year-1, and is characterized as a life zone of Tropical Dry Forest (Bs-T) (5).

Animals and treatments. Thirty-six F1 *Bos taurus* x *Bos indicus* whole males were used with an initial weight of 347±20 kg and an average age of 18 months, which were randomly distributed in the experimental treatments. Prior to the study, a clinical examination was performed and dewormer albendazole® was administered in all the animals. The animals were previously subjected to an adaptation period of 21 days before starting the experimental period. Each animal was housed in an individual pen 3m wide by 4.5m long, with a screwed wooden side fence and a cement floor. Approximately 50% of the corral area was covered, and it had linear feeders and drinkers (canoe type) 70cm long, 30cm deep, and 35cm wide in cement.

The treatments were: T_1 = 85% forage: 15% concentrated, T_2 = 75% forage: 25% concentrated, T_3 = 65% forage: 35% concentrated and T_4 = 55% forage: 45% concentrated, these proportions were based on the animal's dry matter intake. The feed was offered twice a day at 08:00 and 16:00, the animals had water ad libitum. As a source of forage, *Pennisetum* sp. grass was used, which was previously established in an area of 10 ha. Forage was cut by machinery daily and was minced to a particle size between 1-2 cm. The cutting age of the forage ranged from

45 to 50 days. The concentrate was made using raw materials and by-products available in the region, including cottonseed (*Gossypium* sp.), palm kernel cake (*Elaeis guineensis*), molasses, urea, mineral premix, dicalcium phosphate, and calcium carbonate ($CaCO_3$) (Table 1 and 2).

Table 1. Bromatological composition of the ingredients used in the experimental diets.

Ingredients	DM (%)	CP (%)	EE (%)	MM (%)	NDF (%)	ADF (%)	NFC (%)	TDN (%)	ME (Mcal/kg)	NEm (Mcal/kg)	NEg (Mcal/kg)
Elephant Grass	28.0	4.6	2.5	6.4	73.1	63.4	13.4	55.0	2.0	1.1	0.6
Cotton Seed	91.0	21.2	17.5	4.4	46.8	36.9	10.1	84.5	3.1	2.1	1.4
Cotton skin	89.6	4.2	1.6	3.6	85.6	66.9	5.0	42.0	1.5	0.7	0.1
Rice flour	88.6	13.8	14.5	8.5	25.6	15.2	37.6	83.4	3.0	2.0	1.4
Kernel bran	93.7	14.0	11.7	3.4	64.6	55.9	6.3	62.0	2.2	1.4	0.8
Molasses	65.3	4.7	1.5	8.9	0.0	0.0	84.9	72.0	2.6	1.7	1.1
Urea	99.0	286.0	0.0	0.0	0.0	0.0	0.0	100.0	3.6	2.5	1.8

DM: dry matter; CP: crude protein; EE: ethereal extract; MM: mineral matter; NDF: neutral detergent fiber; ADF: acid detergent fiber; NFC: non-fibrous carbohydrates; TDN: total digestible nutrients; ME: metabolizable energy; NEm: net energy for maintenance; NEg: net energy for gain.

Table 2. Percentage and bromatological composition of experimental diets.

Ingredients	Treatments			
	1	2	3	4
Pennisetum purpureum	85.00	75.00	65.00	55.00
Cotton Seed	3.90	6.50	9.10	11.70
Cotton skin	2.40	4.00	5.60	7.20
Rice flour	4.05	6.75	9.45	12.15
Kernel bran	3.30	5.50	7.70	9.90
Molasses	0.90	1.50	2.10	2.70
Urea	0.15	0.25	0.35	0.45
Salt	0.09	0.15	0.21	0.27
Calcium Carbonate	0.12	0.20	0.28	0.36
Bicalcium Phosphate	0.05	0.08	0.11	0.14
Premix[1]	0.05	0.08	0.11	0.14
Composition				
CP (%)	6.33	7.48	8.64	9.79
EE (%)	3.83	4.72	5.61	6.50
NDF (%)	69.18	66.57	63.96	61.35
ADF (%)	59.30	56.80	54.90	51.30
NFC (%)	14.40	15.06	15.73	16.40
TDN (%)	57.28	58.79	60.31	61.83
ME (Mcal/kg)	2.07	2.13	2.18	2.24
NEm (Mcal/kg)	1.22	1.27	1.31	1.36
NEg (Mcal/kg)	0.65	0.69	0.74	0.78

DM: dry matter; CP: crude protein; EE: ethereal extract; MM: mineral matter; NDF: neutral detergent fiber; ADF: acid detergent fiber; NFC: non-fibrous carbohydrates; TDN: total digestible nutrients; ME: metabolizable energy; NEm: net energy for maintenance; NEg: net energy for gain.

The forage and concentrate were offered daily. The amount offered was adjusted over time resulting in refusals measuring between 5 and 10% of the total offered. Feed refusals were collected and weighed daily to calculate the dry matter intake (DMI).

Bromatological analysis. Samples of forage and concentrate were collected weekly, packed in plastic bags, and frozen for further analysis. The bromatological composition of the feed was determined according to the methods established by the AOAC (6) for dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), and ashes. Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) according to Van Soest et al (7). Non-fibrous carbohydrates were calculated according to Sniffen et al, (8) and the values of total digestible nutrients (TDN), metabolizable energy (ME), net energy for maintenance (NEm), and net energy for gain (NEp) were taken taking into account the energy contributions of the NRC beef cattle (9) and to Valadares et al (10).

Performance and carcass morphometry. Average daily gain (ADG) was determined by weighing the animals every 30 days, for 6 consecutive periods using an electronic scale. The weighing was carried out in the morning before the first feeding. The feed conversion (FA) was calculated based on the equation:

Where: DMI = Dry matter intake

Once the animals reached a weight equal to or greater than 450 kg, they were transported to a commercial slaughterhouse (CEAGRODEX, Rivera - Huila) and were fasted for 15 hours (h) with access to water ad libitum. Subsequently to veterinary inspection, the animals were stunned using a captive bolt pistol (11). They were immediately hoisted, and a slaughter process was executed. Carcasses were weighed, divided, washed, and labeled. Hot carcass weight was recorded in kg once the slaughter process was completed. The carcass yield was expressed in percentages calculated as a ratio of hot carcass weight to slaughter weight. Morphometric measurements were taken at 12 h post-mortem, using a tape measure, following the ICTA methodology (12). Leg perimeter (LP), canal length (CL), leg length (LL), leg thickness (LT), chest width (CW), loin width (LW), and loin length (LoL) were also evaluated.

Meat quality. Prior to storage in a cold room (-4°C), pH and temperature were monitored in the *Longissimus dorsi* (LD) from three different points. For the pH evaluations, the parameters of the Honikel methodology (13) were followed, and a portable Hanna® digital potentiometer was used. The temperature was determined using a portable digital thermometer (Multi-Thermometer). The pH and temperature measurements were repeated at 3, 6, 12, 24, and 48 h post-mortem.

For color evaluation, samples of the LD muscle were taken between the 12th and 13th ribs at 12 h postmortem. Meat samples were folded in aluminum foil, refrigerated, and then sent to the post-harvest laboratory of the Faculty of Agronomic Engineering of the Universidad del Tolima. The color was measured at 24 h and 48 h post-mortem with a Minolta model CM spectrophotometer with standard D65 illumination and an aperture of 2.54 cm. For the procedure, the CIE L * a * b system incorporated in the spectrophotometer was followed. The LD was dissected in half to obtain similar portions, then 5 photographic shots were taken and the values of the three coordinates were obtained. The average of each of the coordinates was obtained to establish the final value.

A Warner–Bratzler shear blade was used to measure the meat texture. The hardness of the cooked muscle was determined by recording the maximum effort to cut the sample. The samples were cooked on an electric grill until they reached an internal temperature of 70°C. Subsequently, the samples were cooled inside a bag in a chamber at 5°C for 24 h. Once cold, they were cut into prisms 1 cm wide by 3 cm long.

Analysis of the lipid profile. The fatty acid concentration was determined on 16 samples according to the method of Folch, Lee and, Sloane (1957) (14), the process consisted of homogenizing, extracting with Folch solution, filtering, separating, and evaporating the solvents to recover the fat from the hexane. After obtaining the fat without its components, the saponification technique was carried out to release, methylate, and evaluate the concentration of the fatty acid by gas chromatography (15).

Blood metabolites. Four blood samples were collected from all animals during the last four sampling periods. Blood was collected after a fasting period via coccygeal venipuncture

into vacutainer blood collection tubes without anticoagulant. Immediately, the samples were sent under refrigeration to the Veterinary Diagnostic Laboratory - LADIVET, of the Universidad del Tolima. In the laboratory, the blood samples were centrifuged at 2000 rpm for 10 minutes, the serum was refrigerated and stored at -20ºC. Subsequently, blood urea nitrogen (BUN), glucose, beta-hydroxybutyrate (BHB), triglycerides and phosphorus were determined by the spectrometry method using commercial kits and the BTS-350 BioSystems® semi-automatic analyzer equipment.

Statistical analysis. An analysis of variance (ANOVA) was carried out with a confidence level of 95%. Subsequently, a Tukey test for comparisons of mean values was used. The data was analyzed using SAS statistical software. Linear (L) and quadratic (Q) regression analyses were performed for the variables where significant differences were observed.

RESULTS

Animal performance and carcass parameters Bodyweight gain (BWG) and final slaughter weight increased as the inclusion of concentrate in the diet increased ($p<0.05$), from 0.55 kg to 0.67 kg and from 450 kg to 468 kg for treatments with 15% and 45% concentrate, respectively (Table 3). Feed intake, feed conversion, and carcass yield were not affected by the levels of concentrate ($p>0.05$). No differences were observed in carcass morphometric ($p>0.05$).

Table 3. Performance and Carcass characteristics in F1 bulls (*Bos Taurus* x *Bos indicus)* supplemented with different levels of Low-Cost Concentrate.

Items	Treatments				SE[1]	p - value	
	1	2	3	4		L	Q
Initial weight, kg	348.5	347.3	347.6	350.0	2.038	0.945	0.853
Final weight, kg	450.0^{c}	456.5^{bc}	458.5^{b}	468.0^{a}	1.620	0.001	0.855
BWG, kg d^{-1}	0.55^{b}	0.56^{b}	0.63^{a}	0.67^{a}	0.019	0.045	0.663
DMI, kg d^{-1}	7.00	6.56	7.62	7.27	0.116	0.912	0.832
FC	13.06	11.87	12.22	10.94	0.304	0.748	0.931
Carcass Yield (%)	51.05	50.99	52.15	52.34	0.255	0.873	0.802
Carcass characteristics (cm)							
Carcass length	144.1	140.5	137.9	140.9	17.95	0.217	0.434
Perimeter of the leg	101.4	103.3	103.5	104.4	12.83	0.498	0.691
Loin width	14.9	14.8	14.8	14.6	0.85	0.927	1.000
Loin length	86.3	86.1	84.8	82.3	22.3	0.699	0.475

[1]SE: Standard error of the average. Differences between treatments in the row were identified with different letters.

Meat quality. The main parameters of quality evaluation such as carcass temperature (ºC), texture (kg cm^{-2}), pH at 0 and 48 h, did not present differences between treatments ($p>0.05$). Differences were noted ($p<0.05$) for meat color, in the L coordinate ($p<0.05$), presenting an increase as the proportion of the concentrate in the diet increased (Table 4).

Lipid profile. There were observed differences ($p<0.05$) as decreases in saturated caprylic, capric, and tridecanoic fatty as the level of inclusion of the concentrate in the diet increased (Table 5). The proportion of unsaturated and polyunsaturated fatty acids did not differ between treatments ($p>0.05$).

Table 4. Meat Quality Parameters of F1 bulls (*Bos Taurus x Bos indicus*) fed with different levels of low-cost concentrate.

Items	Treatments				SE[1]	P value
	1	2	3	4		
Temp[2] (ºC)	5.80	5.80	6.00	6.10	0.20	0.343
Texture (kg cm^{-2})	6.76	8.16	6.38	7.34	4.80	0.405
pH 0 h	6.54	6.81	6.49	6.56	0.26	0.598
pH 48 h	5.78	6.09	5.86	5.93	0.18	0.519
Color[3]						
L	27.40^{b}	29.08^{b}	30.28^{ab}	32.58^{a}	6.09	0.050
A	14.14	13.55	14.16	14.81	2.45	0.470
b	3.14	2.86	2.95	3.58	1.24	0.591

[1]SE: Standard error of the average; Temp[2]: Temperature of the carcass 12 hours after slaughter. Red color 645-700 nm; yellow color 578, 580 or 582 nm. Differences between treatments in the row were identified with different letters.

Table 5. Fatty acid profile (g per 100 g of muscle) of F1 bulls (*Bos Taurus x Bos indicus)* fed with different levels of concentrate in the diet.

Fatty Acids	Treatments				EPM[1]	p - value	
	1	2	3	4		L	Q
SATURATED							
6:0 Caproic	0.063	0.05	0.024	0.028	0.0004	0.190	0.450
8:0 Caprylic	0.063[a]	0.05[ab]	0.024[b]	0.028[b]	0.0004	0.009	0.449
10:0 Capric	0.073[a]	0.066[ab]	0.061[ab]	0.049[b]	0.0004	0.001	0.760
12:0 Lauric	1.428	1.240	1.489	1.722	0.158	0.362	0.243
13:0 Tridecanoic	0.063[a]	0.054[ab]	0.031[b]	0.034[b]	0.0003	0.001	0.440
14:0 Miristic	8.812	8.269	8.968	9.845	1.054	0.238	0.132
16:0 Palmitic	32.276	31.471	31.869	32.697	0.807	0.217	0.237
18:0 Stearic	18.528	20.896	18.883	20.040	10.035	0.436	0.371
20:0 Arachidist	0.175	0.225	0.224	0.188	0.003	0.077	0.053
22:0 Behenic	0.091	0.104	0.075	0.065	0.0004	0.711	0.857
23:0 Tricosanoic	0.084	0.107	0.059	0.046	0.0009	0.510	0.423
24:0 Tetracosanoic	0.112	0.232	0.146	0.189	0.006	0.634	0.678
MONOUNSATURATED							
14:1n5 – Myristoleic	1.538	0.899	1.389	1.245	0.168	0.257	0.170
15:1 - Pentadecanoic	0.866	0.906	0.903	0.796	0.034	0.723	0.543
16:1n7 – Palmitoleic	3.850	3.194	3.632	3.106	0.616	0.068	0.110
17:1n9 Heptadecanoic	0.994	1.047	0.985	0.965	0.010	0.627	0.662
18:1n9t Elaidic	0.721	0.718	0.820	1.014	0.052	0.071	0.076
18:1n9c Oleic	29.123	28.227	28.606	25.892	11.075	0.156	0.242
20:1n9 Eicosenoic	0.091	0.072	0.077	0.074	0.0002	0.158	0.292
POLYUNSATURATES							
18:2n6c Linoleic	0.865	1.715	1.415	1.518	0.225	0.522	0.291
18:3n3 Linolenic	0.104	0.097	0.082	0.097	0.003	0.438	0.231
20:4n6 Arachidonic	0.081	0.356	0.24	0.361	0.020	0.289	0.348
Saturated	63.453	64.523	63.706	66.714	17.650	0.749	0.607
Unsaturated	35.722	34.520	34.520	32.259	17.902	0.562	0.333
Polyunsaturated	0.721	0.718	0.820	1.014	0.052	0.758	0.609

[1] EPM: Standard error of the average. Differences between treatments in the row were identified with different letters.

Blood metabolites. No significant differences (p>0.05) were found among the steers under the different treatments for blood metabolites (Table 6).

Table 6. Blood parameters in F1 cattle (*Bos Taurus x Bos indicus*) fed different levels of low-cost concentrate.

Items	Treatments				SE[1]	P value
	1	2	3	4		
BUN (mg/dL)	5.41	6.33	6.84	7.11	6.42	0.218
Glucose (mg/dL)	73.78	74.78	76.56	73.69	60.9	0.984
Cholesterol (mg/dL)	196.5	214.1	225.2	199.5	148.9	0.107
Triglycerides (mg/dL)	44	46.06	43.06	41.31	12.69	0.666
Phosphorus (mg/dL)	8.23	8.26	7.76	7.87	0.60	0.142
BHB (mmol/dL)	0.37	0.4	0.34	0.32	0.01	0.119

[1]SE: Average standard error

DISCUSSION

When foods contain a high fraction of NDF and FDA, there is low consumption and low digestibility, diets rich in fiber, do not allow a release of nutrients by microorganisms due to the high indigestible fractions (16). When this occurs there is hormonal activation, especially leptin and ghrelin, related to satiety and a decrease in consumption, generating an inverse influence between consumption and weight gain (17). This may explain the intake behavior, consumption, and weight gain during the study, which is lower compared to studies using diets with the lowest levels of NDF and ADF. Similar results were obtained by (18), in crossbreed steers fed with diets that contained 5%, 35%, and 65% concentrate, and DMI between 6.6 and 8.1 kg d^{-1} was observed. As the concentrate in the diet increased, the DWG improved. Additionally, Alonso et al (19) fed cattle with *Brachiaria brizantha* cv. Marandu and concentrated in the F: C ratios of 80:20, 65:35, 50:50, 65:35 and reported DM consumption of 5.31, 6.43, 8.13, and 9.52 kg d^{-1}.

The difference between this study's results and the reports allows us to inference that the DMI may be affected by multiple factors such as animal performance, nutrient composition of the feed, and the climate conditions.

Carcass parameter values were in accordance with the parameters reported for zebu cattle (20). Carcass length values showed differences. The differences could not be attributed to the diet, but could be traced to the genetic variability within the animals, due to morphological characteristics are parameters with high heritability rates (21), despite the animals being selected to obtain homogeneous groups. The influence given by the animal's diet, due to its breed, is relegated compared to the relevance of the factors associated with the genetic variability and its carcass conformation (22).

The meat quality parameters found in this study did not line up with the expected values for zebu cattle (23). There were no samples with a temperature low enough to stop the bacterial growth leading to beef aging effects. Consequently, it is important to guarantee that the carcass temperatures falling near to 5ºC during the first 12 h post-mortem is imperative to prevent a pH decrease and the dilution of the muscle fibers ensuring to obtain an adequate beef aging result (24). An increase in pH values was observed at 48 h which is relating to the temperature values at 12h. The relationship between temperature and pH is a model that predicts the effect that each one can have on the other through a direct positive correlation (25). Changes in these parameters can also be related to alterations in color, due to the modification in the water retention capacity in the muscle and the transformation of the muscle into the meat.

The Lightness (L*) values and the low value for yellowness (b*) indicate that the meat presented a slightly dark tonality compared to reference values (26). The meat color can be affected by different factors such as intramuscular fat content, animal stress before slaughter, and some age-related complications. A main cause of the lowest L value is animal age. In older animals, the cellular oxygenation capacity decreases, and the myoglobin present does not have a sufficient amount of oxygen; therefore, the energy of the muscle is insufficient for the breakdown of the muscle fibers, increasing retention of water (27). Meat aged from animals under preslaughter stress is affected. It can be inferred that during the transport and/or slaughter process, the animals were affected by stress situations that directly impact the results of this study.

The fatty acid levels reported in this study concurs with results presented by other researchers using crossbred animals (28). The study results indicated a minimal influence of diet on meat fatty acid profile resulting in the variation of their concentration is not being greater than 5% (29,30). Saturated fatty acids are acids mainly originated by the metabolism of bacteria and yeasts present in the ruminal environment (31) and are manifested in milk and meat. When the animals are fed, with high levels of fiber, the ruminal conditions and the ruminal pH allow increasing of acetate production, leading to high levels of saturated fatty acid (32). This may explain the variability shown in the levels of the fatty acid obtained in the treatments with the lowest levels of concentrate. Tricosanoic acid has the same metabolic behavior as the other saturated acid that presented statistical differences. It may have a greater deposition since it is formed by de novo synthesis (33). Consequently, the deposition of fatty acids present in meat will depends on the metabolism carried out by the ruminal microbiota and the production of volatile fatty acids in the rumen. These factors also affect the content of polyunsaturated fatty acid in meat as well.

Blood metabolites are affected by animal metabolism and nutrient availability. The interpretation of their values is essential to identify diseases, metabolic disorders, and management problems to develop solutions to improve feedlot performance: average daily gain (34). BUN levels are metabolic indicators that reflect the balance or imbalance between protein and energy in the diet. In this study, it can be inferred that protein and energy values were slightly low. The high blood cholesterol values observed could be explained by the presence of palm kernel cake in the diet. Palm kernel cake contains a large amount of palmitic acid, which can be found freely in the blood at great levels when metabolized by the animal (35).

In conclusion, the increase in the proportion of concentrate made with agricultural by-products produced in the department of Huila improves the weight gain and the final slaughter weight in F1 bulls (*Bos Taurus x Bos indicus*) in feedlots under the tropical dry forest conditions during the finishing phase. Temperature, texture, pH of meat, and blood metabolites in animals did not change when concentrate levels increased in the diets. The L parameter of meat color increased when the proportion of concentrate increased and the proportion of saturated fatty acids caproic, caprylic, and tridecanoic decreased when the levels of concentrate increased in the diet of crossbred cattle.

Conflict of interest

The authors declare no conflict of interest.

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