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RESEARCH ARTICLE

Evaluation of Nutrient Composition in Feed Supplements Used by Communal Beef Farmers During the Dry Season in Ga-Matlala, Limpopo Province

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Abstract: This study assessed the nutrient composition of feed supplements commonly used by communal beef cattle farmers during the dry season in Limpopo Province of South Africa. A total of seven feed supplements, such as lucerne hay, maize stover, salt licks, calf grower, calf milk replacer, cattle feed pellets, and soybean meal, were sampled and analysed for proximate composition and mineral content. Soybean meal showed the highest crude protein content (35.32%), while salt licks had the highest ash content (99.29%), and calf milk replacer had the highest fat content (15.81%). Moisture content was highest in complete calf grower (9.2%), followed by cattle feed pellets (7.43%). Neutral detergent fiber (NDF) concentrations were highest in maize stover (56.31%), cattle feed pellets (42.52%), and lucerne hay (32.10%). Acid detergent fiber (ADF) content was also higher in maize stover (33.58%) and cattle feed pellets (30.65%). The measured mineral concentrations were evaluated against the nutritional requirements of beef cattle. Calf milk replacer (1.31%), maize stover (1.13%), and lucerne hay (1.08%) contained appropriate calcium concentrations. Lucerne hay had the highest potassium concentration (1.85%), above that of cattle feed pellets (1.67%), calf milk replacer (1.60%), and complete calf grower (1.01%). Magnesium (Mg) was most abundant in maize stover (0.54%), while sodium (Na) was markedly higher in salt licks (51.56%). Phosphorus (P) content was higher in calf milk replacer (0.56%) than in complete calf grower (0.49%). Results also showed that complete calf grower contained the highest copper concentration (19 ppm), while maize stover (565 ppm), cattle feed pellets (504 ppm), and complete calf grower (469 ppm) had elevated concentration of iron (Fe). Manganese (Mn) (101 ppm) and zinc (Zn) (142 ppm) concentrations were also highest in the complete calf grower. Overall, the findings indicate that communal beef farmers used feed supplements that generally met key nutrient and mineral requirements. However, Mg and fat concentrations were found to be excessive in some supplements, whereas concentrations of ADF, K, Na, Cu, Fe, Mn, and Zn were inadequate in certain feedstuffs.

Keywords: Farmers, Cattle, Dry Season, Feed Supplements

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Introduction

Feed Supplements are utilised to enhance the balance of particular nutrient deficiencies, growth rates, reproductive performance, and production while reducing mortality rates (Alagawany et al., 2021). Supplementary feeding can improve an animal's survival during winter and its reproductive success (Sonnenberg et al., 2023). Cattle can utilize feed resources effectively that have minimal alternative uses, such as crop residues, unproductive cropland, and areas unsuitable for tilling, or land that can only yield grasses (Wyngaarden et al., 2020).

The conservation of bulk feed, accessible in the rainy season, or stubble from crops (Unger et al., 2019), in hay or silage form, can be utilized to support herds during times of forage shortages, aiming for sustainable animal production (Balehegn et al., 2022). In the dry season, the available pastures and crop residues are typically scarce and often of low quality, with low levels of energy, protein, and other nutrients (minerals and vitamins) that are necessary to enhance rumen microbial activity (Ayodele, 2021). The feeds present during the dry season contain a significant quantity of dietary fiber, varying between 35 to 48%, which restricts both the consumption and digestibility of these feeds (Egea et al., 2023). Insufficient nutrition during the dry season often leads to diminished body weight and condition scores in adult animals, lower milk production and extended calving intervals in nursing cows, stunted growth, and heightened mortality rates in calves. Poor nutrition is linked to a heightened vulnerability of animals to stress and disease challenges, leading to their performance falling short of the anticipated genetic potential (Ayodele, 2021).

Numerous alternative feeds differ significantly in their nutrient composition, rendering an evaluation or assessment of the feed resources utilized as dry season supplements essential. Regardless of the feed products utilized, the diet must be optimized to fulfil both the needs of the cattle and the objectives of the farmers in a cost-effective manner (Glencross et al., 2020). To create balanced, cost-effective diets for cattle, communal farmers need to grasp the key nutritional content of the feed supplements they utilize. This is due to the fact that numerous feeds are of low quality, prompting farmers to select and utilize solely the best feeds. The aim of the research was to ascertain the nutrient makeup of feed supplements used by communal beef farmers in the dry season at Ga-Matlala, Limpopo Province.

Materials and Methods

Study Site

The research was conducted in three community areas within the Capricorn District Municipality of Limpopo province in South Africa. The three communal areas were Phofu, Phetole, and Madietane. Samples of feed including lucerne hay, maize stover, salt licks, calf grower, calf milk replacer, cattle feed pellets, and soya bean meal were gathered from communal cattle farmers for chemical analysis. The laboratory of the Department of Agriculture and Rural Development Kwa-Zulu Natal (KZN), located in Cedera, Pietermaritzburg, Kwa Zulu Natal Province of South Africa, performed the chemical analysis of feed supplements.

Preparation of Feed Supplements

Feed supplements were freely provided by communal cattle farmers during the dry season. The samples were dehydrated in a covered dry dish using a standard laboratory oven (Henaeus, Model no. T5050). After drying, they were cooled in a desiccator and stored in sealed containers until analysis.

Proximate Analysis

The techniques established by the Association of Official Analytical Chemists (AOAC, 1995) were employed to analyze moisture, protein, fat, ash, ADF, and NDF in the samples. All measurements were performed in pairs. The proximate values were expressed as a percentage. The duplicate samples (each 5 grams) were utilized to determine moisture content by weighing them in a crucible and drying in an oven at 105 °C until a stable weight was achieved. The ash content was determined by ashing at 550 °C for approximately 3 hours. The Kjeldah method (AOAC, 1995) was utilized to assess the protein content by multiplying the nitrogen value by a conversion factor (6.25). Crude fat was transformed into fatty acid by applying a conversion factor of 0.80, as outlined by Jia et al. (2023) and Greenfield and Southgate (2003). The contents of neutral detergent fiber (NDF) and acid detergent fiber (ADF) were assessed using sodium sulfite as outlined by Van Soest et al. (1991).

Mineral Analysis

The mineral contents (elements) in samples: calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), iron (Fe), zinc (Zn), manganese (Mn), and copper (Cu) were measured using the atomic absorption spectrophotometer (AAS-Buck 205), following the procedures outlined by the Association of Official Analytical Chemists (AOAC, 1995). Phosphorus was measured using calorimetric methods (AOAC, 1990). All the measurements were performed in triplicate.

Statistical Analysis

Prior to the analysis, the data was assessed for normal distribution with the Shapiro-Wilk test and for variance homogeneity using Levene's test. Data not adhering to a normal distribution underwent log transformation to satisfy the requirements of normality and equal variances. A one-way ANOVA was subsequently performed to evaluate variations in the nutrient composition of various supplemental feeds. Significance was assessed at $p \leq 0.05$. After the ANOVA, a post hoc analysis was conducted utilizing the Tukey test. All statistical analyses were performed with R statistical software, version 4.4.0.

Results

Protein, Ash and Fat Composition in Different Supplementary Feeds

The protein content of feed samples varied from 3.98 to 35.32%, as illustrated in Fig. 1. Soya bean meal (35.32%) contained the highest protein level, followed by calf milk replacer (19.69%), lucerne hay (18.59%), and complete calf grower (18.1%), all in comparison to the necessary protein range (≥10 to 15%) for beef cattle. Salt licks (3.98%) possessed the least protein content. The ash content percentages in feed samples varied between 6.78 and 99.29%. The greatest ash content of 99.29% was found in salt licks, followed by maize stover at 13.75% and calf milk replacer at 10.53%. The complete calf grower (6.51%) had lower ash content than the required range (10 to 15%) for beef cattle, as illustrated in Fig. 1. The fat content percentages of the feed samples varied from 0.45 to 15.81%, as illustrated in Fig. 1. The fat content of calf milk replacer was the highest at 15.81%. It was succeeded by lucerne hay (3.75%). Salt licks (0.45%) contained the lowest fat content in comparison to the necessary fat content (4.00 to 37.59%).

NDF and ADF and Moisture Composition for Different Supplementary Feeds

Results in Fig. 2 indicated that the moisture levels of feed samples varied from 0 to 10%, in contrast to the necessary moisture range for beef cattle, which is between 10 and 15%. The complete calf grower (9.2%) contained more moisture, followed by cattle feed pellets (7.43%). The lowest moisture content was detected in salt licks (0%). The moisture level in the feed samples was below the necessary moisture for beef cattle. The values of NDF content in feed samples varied from 0.02% to 56.31%, as illustrated in Figure 2. The highest NDF value achieved in maize stover is 56.31% followed by cattle feed pellets (42.52%) and lucerne hay (32.12%) in relation to the necessary NDF level (30%) for beef cattle. The lowest level of NDF was observed in salt licks (0.02%). ADF was highest in maize stover (33.58%) and followed by cattle feed pellets (30.65%), contrasting the needed NDF content (18 to 25.5%), and was lowest in salt licks (0%).

Chemical Composition of the Minerals for Different Supplements

The calcium levels in feed samples varied from 0.25% to 1.31%, as shown in Table 1, which is contrasted with the necessary calcium range (0.18% to 0.53%) and the upper limit for calcium (2%). Calf milk replacer (1.31%), maize stover (1.13%), and lucerne hay (1.08%) contained higher levels of Ca. Soya bean meal (0.25%) contained the lowest calcium content but remained above the required Ca level. The concentration of K in feed samples varied from 0.03 to 2.13% and did not exceed the maximum acceptable K level (3%). Lucerne hay (1.85%) exhibited the highest potassium level, followed by cattle feed pellets (1.67%), calf milk replacer (1.60%), and complete calf grower (1.01%). The lowest K level was observed in maize stover (0.73%) and salt licks (0.03%). The concentration of Mg in feed samples varied from 0.03 to 0.54%. The greatest Mg concentration was recorded in maize stover (0.54%), with lucerne hay (0.36%) following, when compared to the necessary Mg range (0.05-0.25%) and the highest permissible Mg level (0.40%). Salt licks (0.03%) contained the least amount of Mg.

The level of Na in feed samples varied between 0.14 and 51.56%. The highest Na level of 51.56% found in salt licks surpasses both the necessary Na range (0.06-0.10%) and the maximum permissible Na level (10%). Subsequently, an appropriate level of sodium (Na) was present in the calf milk replacer (1.06%). The lowest Na content was observed in maize stover (0.14%). The P level in feed samples varied from 0.18 to 0.56%, either meeting the minimum required P range (0.18

to 0.37%) or exceeding the maximum permissible P level (1%). Calf milk replacer (0.56%) contained a more suitable level of P, while the complete calf grower had 0.49%. Maize stover (0.18%) contained the lowest amount of P (Table 1).

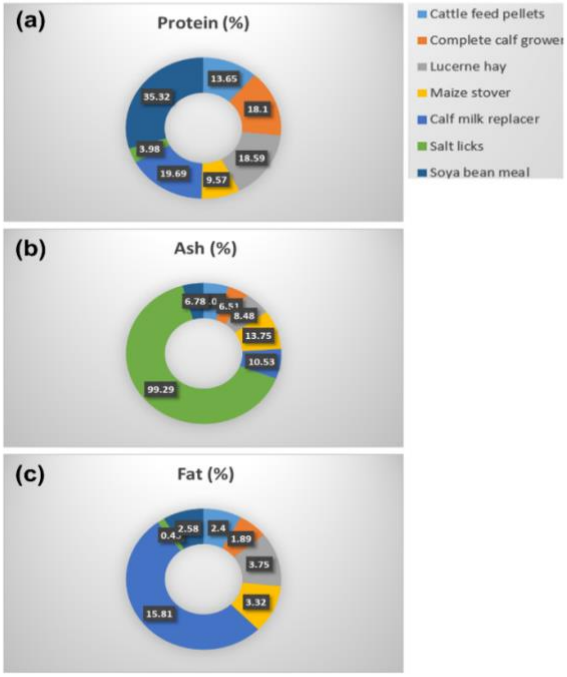

Fig. 1: Chemical composition of the main nutrients: Protein: (a), Ash (b) and Fat (c) for different supplementary feeds

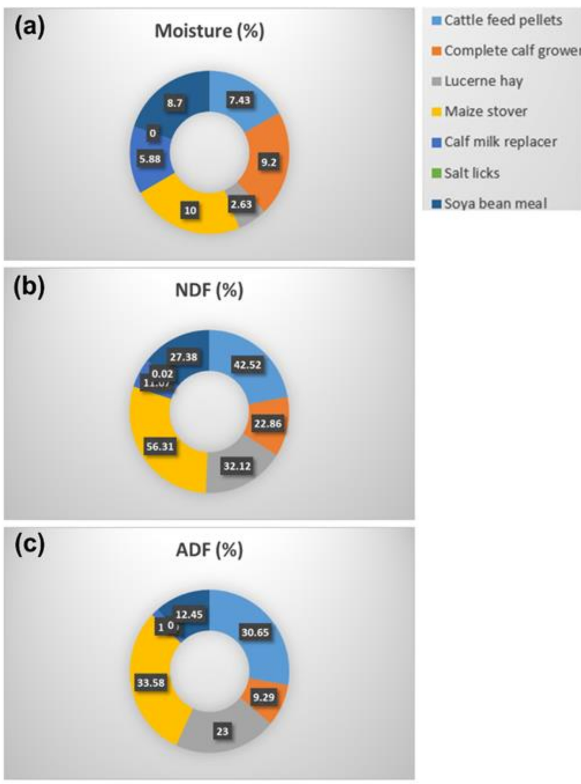

Fig. 2: Chemical composition of the main nutrients: Moisture (a), NDF (b) and ADF (c) for different supplementary feeds during the dry season. NDF: Neutral detergent fiber; ADF: acid detergent fiber

The micromineral composition of feedstuffs is presented in Table 2. The Cu concentration in feed samples varied between 1 and 19 ppm. Complete calf grower had higher levels of Cu (19 ppm), followed by soya bean meal (12 ppm), lucerne hay (8 ppm), and maize stover (7 ppm) when compared to the necessary Cu range (4 to 10 ppm) and the upper limit of Cu (115 ppm). Salt licks (1 ppm) contained the lowest amount of Cu. The Fe concentration in feed samples varied from 138 to 565 ppm, exceeding the recommended Fe range (50-100 ppm) but remaining below the highest permissible Fe level (1000 ppm). Maize stover (565 ppm), cattle feed pellets (504 ppm), and complete calf grower (469 ppm) contained high Fe levels, while lucerne hay (138 ppm) had the lowest Fe level (Table1).

The level of Mn in feed samples varied between 6 and 101 ppm. Complete calf grower (101 ppm) contained a higher amount of Mn than maize stover (75 ppm) compared to the needed Mn range (20-40 ppm), but remained below the maximum tolerable Mn limit (1000 ppm) (Table 2). The lowest concentration of Mn was detected in salt licks (6 ppm). The level of Zn in feed samples varied between 34 and 142 ppm. Complete calf grower (142 ppm) contained a higher level of Zn, followed by maize stover (69 ppm) and calf milk replacer (57 ppm), all exceeding the required Zn range (20-40 ppm) but remaining below the maximum permissible level (500 ppm). Lucerne hay (34 ppm) contained the lowest level of Zn.

Table 1: Macromineral composition of Feedstuffs

Feed type	Ca (%)	K (%)	Mg (%)	Na (%)	P (%)
Cattle feed pellets	0.66 [a]	1.67 [a]	0.24 [b]	0.35 [c]	0.29 [a]
Complete calf grower	0.7 [a]	1.01 [b]	0.25 [b]	0.37 [c]	0.49 [a]
Lucerne hay	1.08 [a]	1.85 [a]	0.36 [b]	0.31 [c]	0.27 [a]
Maize stover	1.13 [a]	0.73 [b]	0.54 [a]	0.14 [c]	0.18 [a]
Calf milk replacer	1.31 [a]	1.6 a	0.14 [b]	1.06 [b]	0.56 [a]
Salt licks	0.57 [a]	0.03 c	0.03 [b]	51.56 [a]	n.d
Soya bean meal	0.25 [a]	2.13 a	0.25 [b]	n.d	n.d

[abc] Means within the same column having different superscripts are significantly different ($p<0.05$), nd - not detected

Table 2: Micro Mineral composition of feedstuffs

	Micro mineral composition			
Feed type	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
Cattle feed pellets	504 [a]	48 [b]	41 [c]	3 [b]
Calf grower	469 [a]	101 [a]	142 [a]	19[a]
Lucerne hay	138 [b]	36 [b]	34 [c]	8 [b]
Maize stover	565 [a]	75 [a]	69 [b]	7 [b]
Calf milk replacer	242 [b]	26 [b]	57 [b]	4 [b]
Salt licks	171 [b]	6 [c]	n.d	1 [b]
Soya bean meal	247 [b]	35 [b]	n.d	12 [ab]

[abc] Means within the same column having different superscripts are significantly different ($p<0.05$), nd - not detected

Discussion

The research showed that the greatest protein content was found in soya bean meal, followed by calf milk replacer, lucerne hay, and complete calf grower. Dozier et al. (2023) noted comparable findings, asserting that soybean meal contained high protein levels due to proper processing. Excess protein that surpasses animal needs can result in resource wastage and may negatively impact the environment, as much of the surplus protein is excreted as NH3 in urine and feces (Cortese et al., 2019). The findings also showed that the least protein was acquired in salt licks. This is due to the fact that salt licks are not used in animal diets to provide protein, but rather as mineral supplements alongside what is gathered from forages. Consequently, it is insufficient to sustain rumen microbial functions and energy provision, making it inadequate for use alone in animal nutrition as a protein source. These results conflicted with the findings of Brar and Nanda (2020), who stated that urea mineral block delivers crude protein that is typically lacking in dry feed.

In the current research, a significant ash content value was observed in salt licks. This is due to the fact that salt licks are probably tainted with growing levels of soil. This aligns with the results of DuPonte (2022), who discovered that elevated ash levels in feeds can reduce the quantity of nutrients accessible to the animal. Ferket et al. (2022) indicate that surplus minerals may lead to skeletal and joint issues in animals, thus feeds with elevated ash levels should be shunned. The calf grower also resulted in the lowest ash content. This aligns with the results of Olijhoek et al. (2020), who discovered that low ash levels in feed aid in managing urinary tract issues in livestock.

The study's findings revealed that the calf milk replacer had the highest fat content. This result differs from that of Gautam et al. (2016), who reported fat levels ranging from 3% to 5.5%. They also concluded that fat content exceeding 6% in feed may cause digestive disturbances, diarrhea, and reduced feed intake. Salt licks were discovered to possess the least amount of fat. This is due to the salt licks being completely solid and dry.

The findings showed a suitable moisture level in the complete calf grower, followed by cattle feed pellets. This is due to the fact that the feed samples were not completely solid feeds. The findings also showed no moisture levels in salt licks. Rasby and Walz (2018) reported similar findings, noting that beef cattle consuming feeds with high water content had decreased water intake, whereas feeds with low water content led to increased water consumption. Govender et al. (2017) stated that the moisture level in feeds ranges from nearly 85% in certain pastures to 10% to 15% in preserved, dried feed. The highest NDF values were found in maize stover, cattle feed pellets, and lucerne hay, while salt licks showed lower levels. Gandhi (2009) reported comparable findings, indicating that the forage sample with higher NDF produced significantly more milk or weight gain compared to the forage sample with lower NDF. When the NDF is low, an alternative is to replace the forage with a different one that has better NDF digestibility or to include highly digestible fiber products.

ADF was higher in maize stover and cattle feed pellets, but lower in salt licks. As stated by DuPonte (2022), ADF should be less than NDF content, and the gap between them indicates the quantity of hemicellulose available. According to the study's findings, the ADF of maize stover and cattle feed pellets exceeds that of NDF. Consequently, because ADF impacts a feed's digestibility, increased ADF levels correlate with decreased cattle digestibility (Andrae et al., 2023).

Mineral elements are crucial for the nutrition of beef cattle. Palomares (2022) stated that a vital mineral element is required to demonstrate that a diet deficient in any beef cattle can lead to deficiency symptoms in animals. This study involved the analysis of feed samples and the mineral element composition of primary elements like calcium, potassium, sodium, and phosphorus, as well as copper, iron, manganese, and zinc in the feeds.

The outcomes indicated that the examined feed samples neither had a deficiency nor an excess of Ca and P levels. This suggests that the feed samples have sufficient amounts of Ca and P. Dixon et al. (2020) state that cattle provided with the recommended levels of Ca and P for beef had enhanced feed consumption, improved bone development, and superior growth performance.

The findings of the current study revealed that Mg levels in maize stover exceeded the nutrient needs suggested for beef cattle. Comparable findings were presented by Mamun et al. (2023), who mentioned that the severity and degree of diarrhoea were closely linked to the elevated Mg levels.

The lowest levels of K, Mg, Cu, and Mn found in salt licks suggest a deficiency. This aligns with the findings of Miller (2017), who mentioned that salt licks are deficient in certain minerals as they include crucial mineral nutrients from salt deposits along with trace minerals like phosphorus, iron, zinc, and calcium. Additionally, the greatest concentration of Na found in salt licks is due to Na having a higher salt content compared to other minerals.

The current research also found a low concentration of Cu in cattle feed pellets. Fadlalla (2022) noted comparable findings, indicating that a lack of copper in cattle diets leads to lower intake and growth, diminished fertility and libido, retained placentas, abortions and stillbirths, reduced birth weights, and inadequate calf performance. Therefore, adding this mineral to feeds lacking it cannot solely suffice in animal feeding.

Conclusion

The research emphasizes the critical role of nutritional management in enhancing cattle productivity. By optimizing feed supplements and addressing nutritional deficiency, cattle farmers can improve the health and productivity of their herds, ultimately contributing to increased food security and sustainable livestock production. To enhance nutrition, feed resources should be utilized alongside additional nutrient sources. Maize stover and Lucerne hay must be treated with urea/alkaline to enhance digestibility.

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Authors' Contributions

BG and MG conceptualised and designed the work. MTR collected the data. BG and MG analysed the data. MTR and BG visualised the results. MTR wrote the paper. BG and MG proofread the manuscript. The authors read and approved the final manuscript.

Ethics

This study was approved by the Turfloop Research Ethics Committee from the University of Limpopo, South Africa with ethical clearance number TREC/125/2021:PG. Interviews were only conducted after consent forms had been signed indicating the willingness to participate freely.

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