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RESEARCH ARTICLE

Assessment of Nutritional Characteristics and Mineral Composition of Badara Plateau Pasture, Çamlıhemşin, Rize, Türkiye

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ABSTRACT

This two-year study (2023–2024) aimed to evaluate the forage quality and nutritional composition of the Badara Plateau pasture, a high-altitude rangeland located in the Çamlıhemşin district of Rize Province, in northeastern Türkiye. Plant samples were systematically collected from twelve distinct sites during July of each year, coinciding with peak biomass production. The samples were analyzed for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), acid detergent protein (ADP) and key macro minerals (P, K, Ca, Mg) using Near-Infrared Reflectance Spectroscopy (NIRS). In addition, several derived nutritional parameters were calculated, including digestible dry matter (DDM), dry matter intake (DMI), relative feed value (RFV), digestible energy (DE), and metabolizable energy (ME). The average dry matter yield was 92.04 kg da^{-1}. The average CP content was 16.14%, reflecting a high nutritional quality of the forage. Fiber content, represented by ADF (31.99%) and NDF (66.08%) values, indicated moderate digestibility and intake potential. The mineral analysis revealed adequate levels of essential macro elements, with balanced Ca/P (5.21) and K/(Ca+Mg) (0.91) ratios. Overall, the findings of this study offer critical insights into the nutritive value and potential carrying capacity of the Badara Plateau rangeland and can inform the development of sustainable grazing strategies for comparable alpine ecosystems in the region.

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1. Introduction

The economic sustainability of livestock production closely tied to feed costs, a substantial component of operational expenditure, which constitute a major proportion of total production costs. Among feed resources, natural and cultivated pastures represent the most cost-effective source of roughage and are fundamental to the sustainability of livestock systems, supplying approximately 70% of the global roughage requirements for ruminants (Lund, 2007). However, the combined effects of rapid global population growth, intensifying climate change, and economic volatility are exerting increasing pressure on the availability and quality of forage derived from these critical ecosystems. Furthermore, the conversion of pasturelands to alternative land uses and the widespread incidence of overgrazing are severely undermining both the productivity and ecological resilience of these rangelands.

Overgrazing stands as a main cause of pasture degradation, particularly in arid and semi-arid regions (Holechek et al., 2011; Snyman, 2005). This degradation manifests in several detrimental ways, including reduced pasture productivity, deterioration of soil physical and chemical properties (Beukes

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& Cowling, 2003), and increased vulnerability to soil erosion. Moreover, overgrazing intensifies the spread of unpalatable and invasive plant species, diminishes overall vegetative cover, and ultimately results in substantial reductions in aboveground biomass production. (Çomaklı et al., 2012; Tongway et al., 2003). These consequences not only detrimentally affect the productivity and sustainability of livestock systems, but also have far-reaching ecological implications, including the loss of biodiversity and the degradation of essential ecosystem services.

Both the quantity and quality of roughage derived from pastures are key determinants of the efficiency and sustainability of livestock production systems (Heitschmidt et al., 1995). As such, ecologically responsible pasture management practices are essential to maintain and enhance the functionality of these ecosystems. Protecting existing pasture ecosystems and implementing effective rehabilitation strategies in vulnerable areas are critical for ensuring long-term productivity and ecosystem health. Achieving these objectives requires a comprehensive assessment of current pasture conditions and the underlying factors contributing to their degradation. A detailed characterization of pasture vegetation is an essential prerequisite for developing and implementing any effective rehabilitation strategy. Therefore, a thorough evaluation of botanical composition, yield, and quality characteristics of different pasture sections is crucial before initiating any rehabilitation interventions, especially in areas exhibiting spatial heterogeneity in soil properties, topography, and plant cover. Such an evidence-based approach enables the formulation and application of site-specific, targeted rehabilitation strategies, thereby enhancing their effectiveness and contributing to the broader objective of sustainable pasture management (Alay et al., 2016; Çınar et al., 2014).

The nutritional value of feed derived from both natural pastures and cultivated forage crops is closely linked to overall forage quality. This encompasses key attributes such as palatability, animal intake, digestibility, the presence of anti-nutritional compounds (e.g., toxins), chemical and morphological composition, and energy and protein content. Furthermore, various environmental factors, including climatic conditions (temperature and precipitation), seasonal variations, the relative proportions of grasses and legumes, altitude, and aspect, can significantly influence forage quality (Kaya, 2008; Kirilov, 2001). A comprehensive understanding of these complex interactions is essential for optimizing livestock nutrition, promoting sustainable pasture utilization, and ensuring the long-term viability of grazing systems.

This study aims to evaluate the livestock carrying capacity and nutritional potential of Badara Plateau pasture, located within the Çamlıhemşin district of Rize province in the Eastern Black Sea Region of Türkiye, by comprehensively analyzing the nutritional value and mineral composition of its constituent vegetation. This research will contribute to enhanced livestock production and the long-term conservation of this valuable resource, providing a model for sustainable pasture management in similar high-altitude ecosystems.

2. Materials and Methods

This research was conducted in Badara Plateau pasture, located in the Çamlıhemşin district of Rize province, within the Eastern Black Sea Region of Türkiye, an area recognized for its remarkable natural beauty and rich biodiversity. The research site is positioned at an approximate altitude of 1850 meters above sea level, approximately 30 km from the district center. The grazing period in Rize province generally starts on May 15 and ends on October 31. The geographical location of the study area is illustrated in Figure 1. Representative photographs of the site's characteristic features, including topography, vegetation cover, and dominant plant communities, are presented in Figure 2, providing a visual representation of the study environment.

Soil samples collected from Badara Plateau were analyzed to determine key soil properties. The analysis revealed the following characteristics: The soil texture was classified as clay loam with a saturation percentage of 75.9%. The soil exhibited a strongly acidic reaction with a pH of 4.48. The total salt content was low (0.14%), indicating a low salinity level. The lime content was also low (0.11%). The organic matter content was found to be 3.27%, which is considered sufficient. Available phosphorus (P_2O_5) and potassium (K_2O) levels were 11.24 kg da^{-1} and 62.45 kg da^{-1}, respectively, both indicating sufficient levels. Rize province, where the study area is located, experiences a temperate climate characterized by substantial precipitation. Analysis of long-term meteorological data obtained from the Turkish State Meteorological Service (MGM) indicates an average annual temperature of 14.5 °C and a high annual precipitation total of 2300 mm (T.C. Çevre, Şehircilik ve İklim Değişikliği Bakanlığı, 2025).

Figure 1. Location of the study area on the map (Google Earth).

Figure 2. Some photos taken from the study area.

In order to determine the nutrient quality values, plant material was collected from twelve different points in the open grazing area of Badara Plateau pasture in July 2023 and 2024, coinciding with the peak period of biomass production. At each sample point, vegetation was harvested at ground level using 50 × 50 cm quadrats to ensure representative sampling. Immediately after harvesting, fresh weights were measured *in situ* using a portable precision balance to minimize moisture loss. Samples were then oven-dried at 70 °C for 48 hours to achieve a constant dry weight, which was subsequently used to calculate yield per unit area (kg da^{-1}). The dried plant material was ground and homogenized using a mill equipped with a 1 mm sieve for subsequent chemical analyses.

The concentrations of crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), acid detergent

protein (ADP), and the minerals phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) were determined using Near-Infrared Reflectance Spectroscopy (NIRS) with a Foss NIR Systems Model 6500 Win ISI II v1.5 instrument. NIRS was selected for its rapid, non-destructive, and cost-effective analysis of multiple constituents, enabling efficient processing of a large number of samples.

Several key nutritional parameters were calculated based on ADF and NDF values using established equations. Digestible dry matter (DDM) was calculated using the equation: DDM = 88.9 – (0.779 × %ADF) (Oddy et al., 1983). Dry matter intake (DMI) was estimated using the equation: DMI = 120 / (%NDF) (Sheaffer et al., 1995). Relative feed value (RFV) was calculated as: RFV = (DDM × DMI) / 1.29 (Sheaffer et al., 1995). Digestible energy (DE) was estimated using the equation: DE = 0.27 + 0.0428 × (%DDM) (Fonnesbeck et al., 1984), and metabolizable energy (ME) was calculated as: ME = 0.821 × DE (Mcal kg^{-1}) (Khalil et al., 1986). These calculated parameters provide valuable estimates of forage quality and potential animal performance.

Furthermore, the ratios of Ca/P and K/(Ca+Mg) were calculated to assess the balance of macro elements, which is crucial for animal health and metabolic functions (İ. Aydın & Uzun, 2002; Polat & Bayraklı, 2019). Maintaining appropriate mineral ratios is essential for preventing nutritional imbalances and optimizing animal productivity.

Descriptive statistical analyses were performed on the collected data for all examined parameters using JMP statistical software. Descriptive statistics, including means, standard deviations, and ranges for each parameter, were calculated.

3. Results and Discussion

Table 1 presents the summary of the nutrient composition of grass samples collected from Badara Plateau pasture over the two-year study period (2023–2024). These data provide a comprehensive evaluation of the pasture's nutritional quality and reveal potential year-to-year differences in nutrient concentrations.

Table 1. Nutrient content and quality of Badara Plateau pasture: analysis of fresh and dry yield, fiber, protein, and mineral composition (average±standard deviation).

Features Analyzed	1.Year	2.Year	Average
Fresh Yield (FY) (kg da^{-1})	408.00±17.10	364.00±16.86	386.00
Dry Yield (DY) (kg da^{-1})	104.00±9.97	80.08±6.18	92.04
Crude Protein (CP) (%)	16.29±0.82	15.99±0.48	16.14
Acid Detergent Fiber (ADF) (%)	33.15±3.05	30.83±1.44	31.99
Neutral Detergent Fiber (NDF) (%)	64.91±3.76	67.25±5.70	66.08
Acid Detergent Protein (ADP) (%)	1.24±0.06	1.19±0.04	1.22
Digestible Dry Matter (DDM)	63.08±2.37	64.88±1.12	63.98
Dry Matter Intake (DMI)	1.85±0.16	1.78±0.11	1.82
Relative Feed Value (RFV)	90.40±9.01	89.75±9.73	90.07
Digestible Energy (DE) (Mcal kg^{-1})	2.97±0.10	3.05±0.08	3.01
Metabolic Energy (ME) (Mcal kg^{-1})	2.44±0.04	2.50±0.08	2.47
Phosphorus (P) (%)	0.34±0.05	0.29±0.02	0.32
Potassium (K) (%)	1.78±0.21	1.49±0.13	1.64
Calcium (Ca) (%)	1.56±0.25	1.69±0.39	1.63
Magnesium (Mg) (%)	0.16±0.04	0.19±0.07	0.18
Ca/P	4.59±0.13	5.83±1.22	5.21
K/(Ca+Mg)	1.03±0.07	0.79±0.04	0.91

Table 1 summarizes the nutritional composition of forage samples collected from the Badara Plateau pasture during the 2023 (1st year) and 2024 (2nd year) growing seasons. The average fresh yield (FY) across both years was 386.00 kg da^{-1}, with values of 408.00±17.10 kg da^{-1} and 364±16.86 kg da^{-1} for the first and second years, respectively. The average dry yield (DY) was 92.04 kg da^{-1}, with values of 104±9.97 kg da^{-1} in the first year and 80.08±6.18 kg da^{-1} in the second year. The average crude protein (CP) content was 16.14%, with limited interannual variation (16.29±0.82% and 15.99±0.48% for the first and second years, respectively). Acid detergent fiber (ADF) averaged 31.99%, while neutral detergent fiber (NDF) averaged 66.08%. The Acid Detergent Protein (ADP) content of the pasture was found to be 1.22%, indicating a moderate level of protein availability for livestock. Digestible dry matter (DDM) averaged 63.98%, dry matter intake (DMI) averaged

1.82, and relative feed value (RFV) averaged 90.07. Digestible energy (DE) and metabolizable energy (ME) averaged 3.01 Mcal kg^{-1} and 2.47 Mcal kg^{-1}, respectively. Mineral analysis revealed average concentrations of 0.32% for phosphorus (P), 1.64% for potassium (K), 1.63% for calcium (Ca), and 0.18% for magnesium (Mg). The average Ca/P ratio was 5.21, and the average K/(Ca+Mg) ratio was 0.91.

The results indicate that the Badara Plateau pasture exhibits moderate to good nutritional quality. The crude protein (CP) content, averaging 16.14%, suggests adequate protein levels for most grazing livestock. The fiber content, as indicated by ADF (31.99%) and NDF (66.08%), is within acceptable ranges for good forage digestibility and intake. ADP value was found to be 1.22%. ADP indicates a potential limitation in protein availability for livestock, as some proteins can bind to cellulose and lignin and become indigestible, especially if storage methods are inadequate or feed is stored with high moisture content, leading to heating (Yavuz et al., 2009). Furthermore, the calculated values of digestible dry matter (DDM) at 63.98%, dry matter intake (DMI) at 1.82, and relative feed value (RFV) at 90.07 reinforce the overall assessment, suggesting that the pasture is capable of supplying sufficient energy and essential nutrients to support the maintenance and productivity of grazing animals.

The interannual variation in dry yield (DY) is notable, with a a marked decline observed in the second year of the study. This could be attributed to various factors such as differences in precipitation, temperature, or grazing pressure between the two years. Further investigation into these factors could provide valuable insights into pasture management strategies. Although there was a considerable difference in fresh yield between the two years, the crude protein content remained relatively stable between years, indicating consistent protein quality.

The mineral composition analysis indicated adequate concentrations of essential macronutrients, including phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg). The Ca/P ratio, averaging 5.21, is within the recommended range for most livestock species, although there was variation between years. The K/(Ca+Mg) ratio, averaging 0.91, also suggests a balanced mineral profile. These balanced mineral ratios are essential for preventing metabolic disorders and ensuring optimal animal health.

This study evaluated the nutritional characteristics of Badara Plateau pasture over two years (2023-2024). The findings, summarized in Table 1, provide important insights into the forage quality and potential carrying capacity of this high-altitude ecosystem. Comparing our results with previous studies conducted in different regions of Türkiye reveals interesting trends and variations.

The average DY observed in Badara Plateau (92.04 kg da^{-1}) was notably lower than the maximum DY reported by Kılıç (2018) in Trabzon (827.3 kg da^{-1}). This substantial difference may be attributed to various factors, including altitudinal variations, differences in soil properties, botanical composition of the pastures, and variations in climatic conditions, particularly precipitation patterns and temperature regimes. The higher altitude and potentially different plant communities in Badara Plateau could have contributed to the lower biomass production.

The average CP content in Badara Plateau pasture (16.14%) is comparable to the findings of Kılıç (2018) (16.6%) and Şahinoğlu (2010) (16.33-18.64%) in Samsun and Nadir (2010) in Tokat (16.48-18.81%). This suggests that Badara Plateau provides a similar protein level to other pastures in these regions. However, studies conducted by Güllap (2010) in Erzurum and Parlak et al. (2015) in Çanakkale reported lower CP values (ranging from 8.26% to 13.18%), indicating the influence of geographical location, specific plant species composition, and environmental factors on protein content. In contrast, A. Aydın and Başbağ (2017)'s study in Karacadağ reported a higher average CP of 19.19%, further highlighting the impact of different ecological conditions on forage quality.

The average ADF (31.99%) and NDF (66.08%) values observed in Badara Plateau are within the ranges reported in some studies but differ from others. Şahinoğlu (2010) reported lower NDF values (46.39-55.21%), suggesting potentially higher intake potential in the pastures they studied. Kılıç (2018) found ADF at 35.7% and NDF at 49.6%, while Nadir (2010) reported considerably lower ADF (24.38-26.84%) and NDF (34.59-36.32%) values. The study of Tutar and Kökten (2019) in Bingöl similarly showed different ADF and NDF rates (34.8-37.4% ADF and 52.5-62.7% NDF), emphasizing the diversity of factors affecting pasture quality. These differences can be attributed to variations in plant maturity at the time of sampling, species composition, and environmental factors. The higher NDF values in Badara Plateau might indicate a more mature stage of plant growth or the presence of plant species with higher fiber content.

The mineral content of Badara Plateau pasture also varied compared to other studies. Phosphorus (P) levels (0.32%) were similar to those reported by A. Aydın and Başbağ (2017) (0.34%). However, potassium (K) levels (1.64%) were lower than those found by Şahinoğlu (2010) (2.32-2.60%) and A. Aydın and Başbağ (2017) (2.42%). Calcium (Ca) content (1.63%) was higher than reported by Şahinoğlu (2010) (0.90-1.33%), while magnesium (Mg) levels (0.18%) were lower than in Şahinoğlu (2010) (0.26-0.36%) and A. Aydın and Başbağ (2017) (0.31%). The Ca/P ratio (5.21) was higher, and the K/(Ca+Mg) ratio (0.91) was generally lower than those reported in other studies. These variations in mineral content likely reflect differences in soil mineral composition, plant species, and environmental conditions.

This study provides valuable data on the nutritional characteristics of Badara Plateau pasture. The variations observed in comparison with previous regional studies underscore the necessity of site-specific evaluations to inform effective and sustainable pasture management strategies. Factors such as; altitude, climate, soil, and botanical composition appear to play significant roles in determining forage quality. These findings contribute to a better understanding of pasture resources in Türkiye and support the development of sustainable grazing practices tailored to the specific conditions of Badara Plateau and similar high-altitude ecosystems.

4. Conclusion

This two-year study (2023–2024) evaluated the nutritional characteristics of Badara Plateau pasture in the Çamlıhemşin district of Rize province, Türkiye. The findings provide valuable insights into the forage quality and potential carrying capacity of this high-altitude ecosystem. The average dry matter yield was 92.04 kg da^{-1}, demonstrating the pasture's capacity for biomass production, although this was lower than some reported yields from other regions, suggesting potential influences of site-specific factors such as altitude (1850 m a.s.l.), soil conditions, and botanical composition. The average crude protein content (16.14%) indicates a good nutritional value for grazing livestock, comparable to other pastures in the region. Fiber content (ADF: 31.99%; NDF: 66.08%) suggests moderate digestibility and intake potential. Calculated nutritional parameters, including DDM (63.98%), DMI (1.82), RFV (90.07), DE (3.01 Mcal kg^{-1}), and ME (2.47 Mcal kg^{-1}), further support the pasture's potential to meet the nutritional requirements of grazing animals. The mineral analysis revealed adequate levels of essential macro elements (P, K, Ca, and Mg), with calculated Ca/P (5.21) and K/(Ca+Mg) (0.91) ratios suggesting a generally balanced mineral profile. However, some interannual variations were observed in yield and mineral content, highlighting the influence of seasonal climatic factors and the importance of continued monitoring. This study contributes to the understanding of pasture resources in the Eastern Black Sea region and provides a basis for developing sustainable grazing management strategies for Badara Plateau and similar high-altitude pastures in Türkiye. Further research should focus on optimizing grazing practices, investigating the impact of climate change on pasture quality, and exploring potential strategies for enhancing forage production and nutritional value.

Compliance with Ethical Standards

This study does not require ethical committee approval.

Conflict of Interest

The author has no conflict of interest to declare.

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