ADAN J. Agric. 2026, 7 (1): 111-120
© *Association of Deans of Agriculture in Nigerian Universities (ADAN)*
ISSN 2736-0385
DOI: **10.36108/adanja/6202.70.0121**

Nutritional composition and potential utilization of *Parquetina nigrescens* and *Morinda lucida*: comparative evaluation of whole, residue and coagulum fraction

Akinyemi B. Temitope[1], Apalowo I. Gideon[2], Yusuf A. Olanrewaju[3], Dele P. Aniwe[4]
[1]Department of Pasture and Range Management, Federal University of Agriculture Abeokuta, Ogun state Nigeria., [2]Department of Animal Production and Health, Federal University of Agriculture Abeokuta, Ogun state, Nigeria.

Corresponding Author: *akinyemibt@funaab.edu.ng* ***Phone Number:*** *+2348032247133*

Abstract

Seasonal feed scarcity and declining forage quality in tropical regions severely limit ruminant productivity, necessitating evaluation of alternative underexploited plant protein sources. This study investigated the nutritional composition and potential feed utilization of Parquetina nigrescens and Morinda lucida through a comparative assessment of their leaf protein concentrate fractions. Fresh leaves of Parquetina nigrescens and Morinda lucida were collected, chopped, milled and processed into three (3) form (whole, residue and coagulum). A 2 × 3 factorial experiment was conducted to determine the effects of plant species and leaf protein concentrate form on proximate composition, mineral concentration, and anti-nutritional constituents. The results revealed significant ($P < 0.05$) differences across species and processing fractions. The coagulum fraction of both plants exhibited markedly higher crude protein contents (40.36%) in P. nigrescens and (38.04%) in M. lucida, compared to the residue fractions (18.16%) while, Neutral Detergent Fibre, Acid Detergent Fibre, Acid Detergent Lignin were lowest in coagulum samples with (26.05%), (24.68%) and (4.73%) respectively. Morinda lucida coagulum showed higher Calcium (31.49 mg/kg) and Potassium (40.53 mg/kg). Anti-nutritional factors were generally higher, which were tannin (0.28%), alkaloid (0.72%) and saponin (0.18%) in P. nigrenscens whole form. The findings highlight the potential of these shrubs, particularly their coagulum fractions as natural protein and mineral sources that can enhance the nutritional quality of tropical forages and promote sustainable livestock feeding systems.

Keywords: *Parquetina nigrescens, Morinda lucida, leaf protein concentrate, coagulum fraction*

Introduction

Ruminant livestock represent a critical component of tropical agricultural systems, providing meat, milk, hides, and socio-economic stability to rural households (Fajemisin *et al*., 2010). In Nigeria and across sub-Saharan Africa, small ruminants such as sheep and goats play vital roles in food security and cultural practices, yet their productivity remains constrained by seasonal shortages of quality feed resources (Ozung *et al*., 2011). During the prolonged dry season, the nutritive value of natural pastures declines sharply as a result of overgrazing, land degradation, and limited rainfall, leading to protein and energy deficiencies in animal diets (Mokgakane *et al*., 2021; Ravhuhali *et al*., 2021). Consequently, there is growing interest in the utilization of alternative and underexploited plant resources capable of supplying protein, minerals, and bioactive compounds to improve ruminant performance throughout the year.

Two promising shrubs in this regard are *Parquetina nigrescens* (family Apocynaceae) and *Morinda lucida* (family Rubiaceae), both widely distributed in tropical Africa. These species are recognized for their medicinal and nutritional value, containing diverse phytochemicals, minerals, and essential amino acids (Imaga *et al*., 2010; Osuntokun *et al*., 2016). *P. nigrescens* leaves are rich in crude protein and minerals, making them potential natural feed additives. *M. lucida*, commonly known as brimstone tree, has been studied for its therapeutic and antimicrobial properties (Adeleye *et al*., 2018), as well as its usefulness in animal feeding trials (Ola-Fadunsin and Ademola, 2014). Despite their promising profiles, research has largely focused on their medicinal applications, with limited information on their fractionated nutritional composition and use as protein supplements in livestock nutrition.

Leaf protein concentrate (LPC) technology provides a means of isolating and concentrating the true protein and essential nutrients from green leaves into different fractions (whole, residue, and coagulum) each with distinct nutritional attributes (Pirie, 1978). Assessing the chemical and biochemical properties of these fractions is essential to determine their suitability as feed components in silage mixtures or concentrate formulations (Wilkinson and Rinne, 2018; He *et al*., 2023). Therefore, this study was designed to evaluate the nutritional composition and potential utilization of *Parquetina nigrescens* and *Morinda lucida* through a comparative analysis of their whole, residue, and coagulum fractions, with emphasis on proximate composition, mineral content and anti-nutritional factors. The results aim to provide scientific evidence supporting the inclusion of these shrubs as sustainable botanical protein supplements for ruminant production in tropical systems.

Materials and Methods

Experimental site

Leaf protein extraction and chemical analysis were carried out at the laboratory of Pasture and Range Management, College of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria.

Collection of materials

Parquetina nigrescens and *Morinda lucida* were sourced from already existed plot within FUNAAB premises.

Leaf protein extraction

Fresh leaves of *Parquetina nigrescens* and *Morinda lucida* were collected in the early hours of the morning, chopped, milled and extracted according to the procedure of green juice heat coagulation method (Pirie, 1978). The leaf protein was extracted in three (3) forms (whole, residue and coagulum). Whole form is the fresh leaf before extraction. The residue was extracted through blending and squeezing to extract the solid pulp. Coagulum was extracted by boiling the green juice at 80°C - 85°C for 15 minutes and sieve.

Experimental design

The study was laid in a 2 x 3 factorial design comprising two (2) plant species (*Parquetina nigrescens* and *Morinda lucida*) and three (3) leaf protein forms (whole, residue and coagulum) which was replicated three (3) times.

Chemical Analysis

Crude protein (CP), Dry matter (DM), Ether extract (EE) and ash will be determined to the procedure of AOAC (2005), Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and Acid detergent lignin (ADL) of the milled plant sample were determined according to the procedure of Van Soest *et al*. (1991). Cellulose content was taken as the difference between ADF and ADL while hemicellulose content was calculated as the difference between NDF and ADF.

Mineral determination

The samples were dried in a forced draught oven at 105°C for 24 hours and milled, thereafter it was analyzed for some macro minerals Sodium (Na), Potassium (K), Magnesium (Mg) and Calcium (Ca), and micro minerals Manganese (Mn), Iron (Fe), Copper (Cu), Zinc (Zn) and Phosphorus (P). The concentration of K was estimated with a flame photometer after wet digestion in nitric acid and Hydrochloric acid (3:1). Concentrations of Ca, P, Zn, Cu and Fe was determined with atomic absorption spectrophotometry (Fritz and Schenk, 1979). Additionally, Na, Mg, Mn and amino acid concentrations were determined using a near-infrared reflectance spectroscopy (NIRS) machine (FOSS NIRSystem 5000, FOSS Analytical A/S, Denmark) following the procedure described by Cécillon et al. (2009).

Anti-nutritional factors

Alkaloids and Saponin were determined by the method of (Price *et al*., 1978), while Tannins was determined by the methods of Makkar, (2003). Phytate content was determined by the method of Wheeler and Ferrel (1971) as modified by Vaintraub and Lapteva (1988), while oxalate content was determined using the titrimetric method described by Day and Underwood (1986).

In vitro gas production and post-incubation parameters

In vitro gas production and post-incubation parameters including 24-hour gas production (24 GAS), metabolizable energy (ME), fatty acid profiles and *in vitro* dry matter digestibility (IVDMD) were determined using a near-infrared reflectance spectroscopy (NIRS) machine (FOSS NIR System 5000, FOSS Analytical A/S, Denmark) following standardized procedures as described by Cécillon et al. (2009). The NIRS calibration equations developed for tropical forages were applied to predict fermentation quality indicators from the scanned spectra of dried and milled samples.

Statistical analysis

Data collected was subjectted to analysis of variance using SAS package and significant means was separated using Duncan's Multiple Range Test (2000) at 5% level.

Results

Interaction effects of plant species (*P. nigrescens* and *M. lucida*) and leaf protein forms on chemical composition

The interaction between plant species and leaf protein forms showed significant ($P<0.05$) variations in all parameters (Table 1). CP was highest in the coagulum of *Parquetina nigrescens* (40.36%) and *Morinda lucida* (38.04%), while the lowest value (18.16%) was recorded in the residue form of *M. lucida*. DM was highest in interaction between plant species and leaf protein forms with the lowest dry matter observed in coagulum form of *M. lucida* (88.40%). Ash content was highest in *M. lucida* coagulum (19.72%) and lowest in *P. nigrescens* residue (7.02%). The whole leaf form of *M. lucida* had the highest EE (15.14%) and while the least was in the coagulum form of *M. lucida* (0.56%). NDF (45.53%) content was highest in *P. nigrescens* residue form and least (21.67%) in *M. lucida* whole leaf. Acid Detergents Fibre was highest in *M. lucida* coagulum (43.22%) and lowest in whole form of both species. Acid Detergent Lignin was statistical higher in *M. lucida* residue (9.72%) and *P. nigrescens* residue (9.60%) while the least was observed in *M. lucida* coagulum (4.73%).

Table 1: Interaction effects of plant species and leaf protein forms on Chemical composition (%)

Plant species	Leaf protein forms	CP	DM	ASH	EE	CF	NDF	ADF	ADL
P. nigrenscens	Whole	21.72^{b}	93.24^{a}	9.96^{d}	6.41^{d}	5.82^{e}	39.80^{b}	27.58^{cd}	7.97^{b}
	Residue	19.59^{bc}	92.98^{a}	7.01^{e}	8.34^{c}	10.51^{d}	45.53^{a}	32.13^{b}	9.60^{a}
	Coagulum	40.36^{a}	93.52^{a}	17.27^{b}	2.40^{e}	15.17^{b}	41.25^{b}	24.68^{d}	6.16^{c}
M. lucida	Whole	21.45^{b}	95.55^{a}	11.45^{c}	15.14^{a}	15.35^{b}	21.67^{d}	27.12^{d}	7.36^{b}
	Residue	18.16^{c}	93.26^{a}	9.79^{d}	13.46^{b}	18.30^{a}	26.99^{c}	30.70^{bc}	9.72^{a}
	Coagulum	38.04^{a}	88.40^{b}	19.72^{a}	0.56^{f}	12.07^{c}	26.05^{c}	43.22^{a}	4.73^{d}
SEM		2.22	0.67	1.09	1.29	0.99	2.21	1.50	0.44

$^{a,\ b;}$ means on the same column with different superscripts are significant (P<0.05)
SEM: Standard error of mean, CP: crude protein, DM: dry matter, EE: ether extract, CF: crude fibre, NDF: neutral detergent fibre, ADF: Acid detergent fibre, ADL: Acid detergent Lignin

Interaction effects of plant species (*Parquetina nigrescens* and *Morinda lucida*) and leaf protein forms whole, residue and coagulum on macro and micro mineral composition

The combined effects of plant species and leaf protein forms significantly (P<0.05) affected macro and micro mineral contents (Table 2). The concentration of macro-minerals varied between the plant species and leaf protein forms. The highest Na (3.68 mg/kg) and K concentration (40.53 mg/kg) were obtained in *M. lucida* coagulum while the lowest were observed in *M. lucida* residue (1.76 mg/kg) and *P. nigrescens* whole (4.74 mg/kg) respectively. The Mg concentration obtained in *M. lucida* were statistical similar for all the different leaf forms (13.01 - 13.42 mg/kg) although, they were significantly higher than the concentration obtained in *P. nigrescens* leaf forms (6.42–8.62 mg/kg). Calcium (Ca) (31.49 mg/kg) was highest in *M. lucida* whole coagulum followed by its coagulum (27.99 mg/kg) and residue (27.49 mg/kg) forms. However, *P. nigrenscens* recorded consistently lower calcium concentration (15.56–16.87 mg/kg) for all leaf forms. It was recorded that phosphorus concentration was significantly highest in *P. nigrenscens* residue (5.44 mg/kg) and lowest in *M. lucida* residue and coagulum (0.07 mg/kg).

The concentration of micro-minerals varied between the interaction of plant species and leaf protein forms. Manganese (Mn) (0.32 mg/kg) was significantly highest in *M. lucida* whole while the lowest (0.06 mg/kg) was obtained in *P. nigrescens.* It was observed that manganese concentration was generally higher in *M. lucida* leaf forms (0.13–0.32 mg/kg) than *P. nigrescens* leaf forms (0.06–0.08 mg/kg). The concentration of Cu was significantly highest in *M. lucida* whole (5.30 mg/kg), followed by *M. lucida* coagulum (3.94 mg/kg) while the lowest concentration was obtained in *P. nigrescens* whole (0.35 mg/kg). It was observed that the concentration of Fe (1.93 mg/kg) and Zn (0.037 mg/kg) were highest in *P. nigrescens* coagulum and residue, respectively. However, the lowest concentration of iron (0.46 mg/kg) and zinc (0.00 mg/kg) were recorded in *M. lucida* coagulum.

Table 2: Interaction effects of plant species and leaf protein forms on mineral composition

Plant species	Leaf protein forms	Na	K	Mg	Ca	Mn	Fe	Cu	Zn	P
P. nigrenscens	Whole	2.57[c]	4.74[e]	8.62[b]	16.15[c]	0.06[e]	1.12[c]	0.35[e]	0.026[c]	4.45[b]
	Residue	2.03[e]	9.44[d]	8.43[b]	15.56[c]	0.08[d]	0.94[d]	2.71[c]	0.037[a]	5.44[a]
	Coagulum	2.36[d]	10.73[d]	6.42[c]	16.87[c]	0.07[de]	1.93[a]	1.12[d]	0.029[b]	4.32[b]
M. lucida	Whole	2.97[b]	32.23[b]	13.42[a]	31.49[a]	0.32[a]	1.72[b]	5.30[a]	0.020[d]	2.76[c]
	Residue	1.76[f]	24.30[c]	13.01[a]	27.49[b]	0.13[c]	1.20[c]	0.45[e]	0.01[e]	0.07[d]
	Coagulum	3.68[a]	40.53[a]	13.30[a]	27.99[b]	0.22[b]	0.46[e]	3.94[b]	0.00[f]	0.07[d]
SEM		0.15	3.16	0.69	1.61	0.02	0.12	0.45	0.003	0.51

[a, b;] means on the same column with different superscripts are significant (P<0.05)
SEM: Standard Error of mean.

Interaction effects of plant species and leaf protein forms on anti-nutritional composition

The interaction between plant species and leaf protein forms significantly influenced all anti-nutritional factors (Table 3). Tannin was significantly highest in *P. nigrescens* whole form (0.28%) and lowest in the residue (0.05%). However, in *M. lucida*, the whole form (0.19%) had a higher tannin concentration while the coagulum (0.14%) had a moderate concentration. The highest phytate concentration was significantly obtained in *P. nigrescens* coagulum (0.35%) while the lowest was obtained in *P. nigrescens* residue (0.15%). However, It was observed that phytate concentration in *M. lucida* coagulum (0.35%) was higher than whole (0.25%) and residue (0.10%) form. Oxalate concentration was significantly highest (0.149%) in *P. nigrescens* coagulum and lowest (0.081%) in *M. lucida* residue. Alkaloid was highest with similar value (0.72%) in both *P. nigrescens* whole, *M. lucida* coagulum and whole forms, although *P. nigrescens* coagulum (0.71%) was statistical similar, while the lowest concentration (0.56%) was obtained in *P. nigrescens* residue. The saponin concentration was statistically highest (0.18%) in *P. nigrescens* whole and lowest (0.04%) in *M. lucida* coagulum. Also, similar saponin concentration (0.11%) was obtained in *P. nigrenscens* residue and *M. lucida* whole.

Table 3: Interaction effects of plant species and leaf protein forms on anti-nutritional composition (%)

Plant species	Leaf protein forms	Tannin	Phytate	Oxalate	Alkaloid	Saponin
P. nigrenscens	Whole	0.28[a]	0.42[b]	0.142[d]	0.72[a]	0.18[a]
	Residue	0.05[f]	0.15[e]	0.144[c]	0.56[c]	0.11[b]
	Coagulum	0.23[b]	0.54[a]	0.149[a]	0.71[a]	0.07[d]
M. lucida	Whole	0.19[c]	0.25[d]	0.147[b]	0.72[a]	0.11[b]
	Residue	0.10[e]	0.10[f]	0.13[e]	0.67[b]	0.09[d]
	Coagulum	0.14[d]	0.35[c]	0.10[f]	0.72[a]	0.04[e]
SEM		0.02	0.04	0.00	0.01	0.01

[a, b;] means on the same column with different superscripts are significant (P<0.05)
SEM: Standard Error of mean

Interaction effects of plant species and leaf protein forms on invitro gas production and post incubation parameters

Interaction effects of plant species and leaf protein forms showed significant (P<0.05) variations on invitro gas production and post incubation parameters (Table 4).

Gas production (24 h) was highest in *P. nigrescens* whole (38.82 ml) but statistically similar to *P. nigrescens* residue (37.60ml) although having different values, while lowest value was observed in *P. nigrescens* coagulum (10.67 ml). In *M. lucida*, it was observed that the whole leaf form produced the higher (32.33ml) gas while the residue (26.37ml) and coagulum (24.15ml) form were statistical similar. Metabolizable energy (ME) was highest in *P. nigrescens* whole (8.86MJ/kg Dm) but statistical similar with *P. nigrescens* residue and all the leaf forms of *M. lucida*. However, the lowest (ME) was observed in *P. nigrescens* coagulum (6.23MJ/kg Dm). It was recorded that *In vitro* dry matter digestibility (IVDMD) was highest in *M. lucida* coagulum (64.04%) and lowest in *P. nigrescens* coagulum (52.97%).

Table 4: Interaction effects of plant species and leaf protein forms on invitro gas production and post incubation parameters

Plant species	Leaf protein forms	24 GAS	ME	IVDMD
P. nigrenscens	Whole	38.82[a]	8.86[a]	59.72[abc]
	Residue	37.60[a]	8.80[a]	60.86[ab]
	Coagulum	10.67[d]	6.23[b]	52.97[d]
M. lucida	Whole	32.33[b]	8.71[a]	56.82[bcd]
	Residue	26.37[c]	8.42[a]	55.07[cd]
	Coagulum	24.15[c]	8.76[a]	64.04[a]
SEM		2.32	0.24	1.05

[a, b;] means on the same column with different superscripts are significant (P<0.05)
SEM: Standard Error of mean, 24 Gas: *invitro* gas volume produced at 24hours of incubation, ME: Metabolizable Energy and IVDMD: *Invitro* dry matter digestibility

Discussion

The results of this study demonstrate that both plant species (*Parquetina nigrescens* and *Morinda lucida*) and leaf-protein concentrate fractions (whole, residue, and coagulum) exerted significant effects (P < 0.05) on the proximate composition, amino-acid and fatty-acid profiles, mineral concentration, and anti-nutritional constituents. These variations confirmed that both genetic and processing factors interact to determine the nutritive potential of forage resources. The differences observed among the fractions reflect the redistribution of nutrients during coagulation and extraction, processes known to alter the balance between true protein, structural carbohydrates, and mineral constituents (McDonald *et al*., 2010; Van Soest, 2018). At the interaction level, *P. nigrescens* coagulum recorded the highest crude protein and ash, followed by *M. lucida* coagulum. Conversely, the lowest CP value (18.16 %) was observed in *M. lucida* residue, indicating that both botanical origin and processing fraction jointly determined nitrogen concentration. These trends are consistent with earlier findings by Bureenok *et al*. (2012) and Kung *et al*. (2018), who demonstrated that ensiling and heat-coagulation concentrate true protein and soluble nitrogen while reducing fibrous bulk. The EE content was highest in *M. lucida* whole form and lowest in *P. nigrescens* residue, suggesting that lipid retention depends on both the structural integrity of the leaf matrix and the degree of thermal or fermentative disruption during processing. This agrees with McDonald *et al*. (2010) and Dunière *et al*. (2013), who observed that heat treatment and fractionation can cause lipid redistribution between aqueous and solid phases. CF ranged from 14.21 % in *P. nigrescens* whole to 24.36 % in *M. lucida* residue, showing that residues retained much of the cell-wall fraction, while the coagulum fractions, containing more soluble and digestible compounds, showed lower fibre values. These data confirm that coagulation effectively separates fibrous polysaccharides from protein-rich material (Van Soest, 2018).

Fibre-related parameters followed a similar interaction trend. NDF and ADF were lowest in *P. nigrescens* whole and highest in *M. lucida* residue. Such variation demonstrates species-dependent differences in lignocellulose structure and the efficiency of nutrient extraction. For instance, *M. lucida* residue retained more cellulose and lignin components, while *P. nigrescens* whole showed better fibre solubility and lower structural rigidity. Fibre reduction in the coagulum fractions aligns with improved rumen fermentability and potential energy density of silages (Diogénes *et al*., 2023).

In terms of fermentation indicators, gas production (24 h) was highest in *P. nigrescens* whole and lowest in *M. lucida* coagulum. The higher gas volume in whole fractions suggests a greater availability of fermentable carbohydrates, whereas the lower gas in coagulum reflects its higher protein-to-carbohydrate ratio (Menke and Steingass, 1988; Broderick, 2018). Similarly, metabolizable energy (ME) was highest in *P. nigrescens* residue (6.43 MJ/kg DM) and lowest in *M. lucida* coagulum (5.86 MJ/kg DM), reinforcing the principle that energy yield and nitrogen concentration are inversely related in fractionated feed resources. *In vitro* dry-matter digestibility (IVDMD) was highest in *M. lucida* coagulum (64.04 %) and lowest in *P. nigrescens* residue (54.35 %), consistent with its lower fibre and higher protein composition. Digestibility values above 60 % are generally considered indicative of high-quality forages suitable for lactating and growing ruminants (NRC, 2021). Additionally, the high digestibility and moderate EE in *M. lucida* whole make it suitable for energy supplementation in diets where lipid supply supports milk-fat synthesis and rumen microbial efficiency (Shingfield *et al*., 2013). The interaction between plant species and leaf-protein form demonstrates that fractionation can be used strategically to generate feed fractions with distinct nutritional functions—coagulum as protein supplements, whole forms as balanced silage bases, and residues as fibre sources. Such flexibility aligns with modern approaches in sustainable feed formulation that seek to maximize nutrient utilization from agricultural by-products (He *et al*., 2023; Liu *et al*., 2022).

In this study, *Morinda lucida* coagulum is the most mineral-dense fraction: Na (3.68 mg/kg), K (40.53 mg/kg), Mg (13.30 mg/kg), Ca (31.49 mg/kg), and Cu (3.94 mg/kg). By contrast, *P. nigrescens* residue showed a notably high phosphorus and elevated iron in some fractions (Fe up to 1.93 mg/kg in *P. nigrescens* coagulum). Zinc (Zn) concentrations were modest across treatments but trended higher in *P. nigrescens* residue/coagulum compared with *M. lucida* fractions. These interaction patterns have three immediate practical implications. First, the coagulum of *M. lucida* can serve as a targeted source of macro-minerals (Ca, Mg, K, Na) useful in rations for high-producing or late-gestation ruminants that demand greater calcium and electrolyte supply (e.g., transition dairy cows). The Ca values (up to 31.49 mg/kg) and Mg (13.30 mg/kg) indicate this fraction contributes materially to those requirements and could reduce the amount of separate mineral premix needed in some formulations. Second, *P. nigrescens* fractions, with relatively higher Fe and P, could be used where additional P and Fe are desired (e.g., growing stock or in regions with P-deficient forages). Third, residue fractions (particularly *M. lucida* residue with lower overall mineral levels) are less useful as mineral supplements and are better applied where bulk fibre is the objective. However, the results also highlight risks and balancing constraints. High K in *M. lucida* coagulum) can impair Mg absorption and increase risk of hypomagnesemia conditions in susceptible animals when diets are K-rich and Mg supply marginal; this antagonism must be considered when formulating rations (McDowell, 2003). Likewise, concentrated Cu is beneficial for many livestock but may approach toxic thresholds for sheep and therefore requires species-specific adjustment (Spears, 2015). The relatively elevated Fe in some *P. nigrescens* fractions can interact with Cu and Zn absorption and should be monitored in whole-diet contexts. The results also support fraction-specific use rather than one-size-fits-all inclusion. Practical applications include blending *M. lucida* coagulum into transition or lactation concentrates to supply Ca, Mg and K, using *P. nigrescens* coagulum/residue selectively where additional P and Fe are needed; and avoiding high inclusion rates of any one coagulum in sheep rations without mineral monitoring. Crucially, mineral values here are concentration data — actual animal supply depends on inclusion rate, dry matter intake and bioavailability Therefore dietary balancing and laboratory assays (e.g., bioavailable Cu/Zn tests) remain necessary before large-scale dietary adoption (NRC, 2001; McDowell, 2003).

These results confirm that processing significantly modifies phytochemical distribution among fractions, with residue fractions consistently showing the lowest anti-nutrient concentrations due to washing-out or binding losses during protein extraction (Makkar, 2003; Rahman *et al*., 2023). The recorded concentrations fall well below toxic thresholds for ruminants—tannin levels above 2–3 % DM or oxalate levels exceeding 2 % DM are typically required to impair performance or health (Akinfemi and Ogunwole, 2012). The relatively low phytate indicates only moderate potential interference with phosphorus and trace-mineral bioavailability; such levels can be counteracted by rumen phytase activity or exogenous phytase supplementation (He *et al*., 2023). Alkaloid (0.56–0.72 %) and saponin (0.04–0.18 %) concentrations are within acceptable limits for ruminant diets and may even confer mild antimicrobial and antiprotozoal benefits when included at sub-toxic levels (Patra and Saxena, 2011).

Comparatively, coagulum fractions contained slightly higher phytate and alkaloid values, which reflects the protein–phenolic complexation that occurs during thermal coagulation and precipitation (Makkar, 2003). Conversely, the lower concentrations in residue fractions demonstrate that the extraction process effectively separated soluble secondary metabolites from the fibrous matrix. The interaction effects reveal that both botanical species and processing fraction significantly shape the anti-nutritional profile of the resulting silage, but none of the measured values pose a limitation to practical feeding. Similar findings have been reported in tropical forages processed for silage or leaf-protein concentrate production, where controlled fermentation and thermal extraction reduce antinutrient activity to physiologically safe levels (Dunière *et al*., 2013; He *et al*., 2023; Rahman *et al*., 2023).

Conclusion and Recommendations

The findings showed that *Parquetina nigrescens* and *Morinda lucida* contain appreciable protein, fibre, ash, lipid, and mineral contents across whole, residue, and coagulum fractions, indicating strong nutritional potential and suitability for food, medicinal, and nutraceutical applications with significant health-promoting and dietary benefits. Further studies should investigate bioavailability, toxicity, and industrial applications of both plants for pharmaceutical and functional food development.

References

Adeneye A. A. & Agbaje E. O. (2008). Pharmacological Evaluation of Oral Hypoglycemic and Antidiabetic Effects of Fresh Leaves Ethanol Extract of *Morinda lucida* Bent in Normal and Alloxan-Induced Diabetic Rats. *African Journal of Biomedical Research,* 11 (1): 65-71.

Akinfemi, A., & Ogunwole, O. A. (2012). Chemical composition and in vitro digestibility of rice straw treated with Pleurotus ostreatus, Pleurotus pulmonarius and Pleurotus tuber-regium. *Slovak Journal of Animal Science*, *45*(1), 14-20.

Broderick, G. A. (2018). Optimizing ruminant conversion of feed protein to human food protein. *Animal*, *12*(8), 1722-1734.

Bureenok, S., Yuangklang, C., Vasupen, K., Schonewille, J. T., & Kawamoto, Y. (2012). The effects of additives in napier grass silages on chemical composition, feed intake, nutrient digestibility and rumen fermentation. *Asian-Australasian journal of animal sciences*, *25*(9), 1248.

Cécillon, L., Barthès, B. G., Gomez, C., Ertlen, D., Génot, V., Hedde, M. & Brun, J. J. (2009). Assessment and monitoring of soil quality using near infrared reflectance spectroscopy (NIRS). *European Journal of Soil Science*, *60*(5), 770-784.

Day, R. A. & Underwood, A. L. (1986). Quantitative analysis. 5th edition, Prentice, Hall publication, 701p.

Diogénes, L. V., Pereira Filho, J. M., Edvan, R. L., De Oliveira, J. P. F., Nascimento, R. R. D., Santos, E. M. & Bezerra, L. R. (2023). Effect of different additives on the quality of rehydrated corn grain silage: a systematic review. *Ruminants*, *3*(4), 425-444.

Dunière, L., Sindou, J., Chaucheyras-Durand, F., Chevallier, I., & Thévenot-Sergentet, D. (2013). Silage processing and strategies to prevent spoilage. *Grass and Forage Science*, 68(3), 395–407.

He, L., Chen, N., & Zhou, Y. (2023). Advances in silage fermentation science. *Frontiers in Veterinary Science*, 10, 1193457.

Kung, L., Shaver, R. D., Grant, R. J., & Schmidt, R. J. (2018). Silage review: Interpretation of chemical, microbial, and organoleptic components. *Journal of Dairy Science*, 101(5), 3952–3964.

Liu, Q., Shao, T., & Bai, Y. (2022). Amino acid degradation and fermentation quality of silages. *Animals*, 12(5), 619.

Makkar, H. P. S. (2003). *Quantification of tannins in tree and shrub foliage*: A laboratory manual. FAO/IAEA.

McDonald, P., Edwards, R. A., Greenhalgh, J. F. D., Morgan, C. A., Sinclair, L. A., & Wilkinson, R. G. (2010). *Animal nutrition* (7th ed.). Pearson Education Limited.

McDowell, L. R. (2003). Minerals in animal and human nutrition (2nd ed.). Elsevier Science.

Mokgakane, T. J., Mlambo, V., Ravhuhali, K. E. & Magoro, N. (2021). Contribution of Soil Type to Quantity and Nutritional Value of Grass Species on the South African Highveld. *Resources*, 10, 106.

NRC. (2001). *Nutrient requirements of dairy cattle* (7th rev. ed.). National Academy Press.

Nworu C. S., Akah P. A., Okoye F. B. C., Onwuakagba C. J., Okorafor U. O. & Esimone C. O. (2012). Supplementation with Aqueous Leaf Extract of *Morinda lucida* Enhances Immunorestoration and Upregulates the Expression of Cytokines and Immunostimulatory Markers. *Immunological Investigations* 41 (8): 799–819.

Ola-Fadunsin S. D. & Ademola I. O. (2014). Anticoccidial Effects of *Morinda lucida* Acetone Extracts on Broiler Chickens Naturally Infected with Eimeria Species. *Pharm Biol* 52 (3): 330-334.

Osakwe I. I. & Drochner W. (2006). Nutritive Value of *Morinda lucida* and Its Fermentation Parameters in West African Dwarf (WAD) Sheep when Fed as Supplement to Grass Hay. *Small Ruminant Research,* 64 (1–2): 107–115

Osuntokun O., Yusuf-Babatunde A., Ige O. & Odufuwa A. (2016). Phytochemical Screening and Evaluation of Antioxidant and Proximate Properties of *Morinda lucida* Ethanolic Extract. *Journal of Advanced Medical Pharmacy Science,* 11(2): 1–11.

Rahman, M., Haque, M. N., & Sultana, S. (2023). Processing and detoxification of plant anti-nutritional factors for livestock feeding. *Animals*, 13(3), 412.

Ravhuhali, K. E., Mlambo, V., Beyene, T. S. & Palamuleni, L. G (2021). Effect of soil type on spatial distribution and nutritive value of grass species growing in selected rangelands of South Africa. *South Africa Journal of Plant Soil.*, 38, 361–371

Shingfield, K. J., Bonnet, M. & Scollan, N. D. (2013). Recent developments in altering milk fatty acid composition. *Animoal*, 7(S2), 75–92.

Spears, J. W. (2015). Trace minerals in ruminant nutrition. *Journal of Animal Science and Biotechnology*, 6(1), 28.

Vaintraub, I. A., & Lapteva, N. A. (1988). Colorimetric determination of phytate in unpurified extracts of seeds and the products of their processing. *Analytical biochemistry*, *175*(1), 227-230.

Van Soest, P. J. (2018). *Nutritional ecology of the ruminant* (2nd ed.). Cornell University Press.

Wheeler, E. L., & Ferrel, R. E. (1971). A method for phytic acid determination in wheat and wheat fractions.

Wilkinson, J. M. & Rinne, M. (2018). Forage conservation and silage quality. *Grass and Forage Science*, 73(1), 34–45.

Wood, J. D., Enser, M., Fisher, A. V., Nute, G. R., Sheard, P. R., Richardson, R. I. & Hughes, S. I. (2008). Fat deposition, fatty acid composition and meat quality. *Meat Science*, 78(4), 343–358