American Journal of Animal and Veterinary Sciences

Research Article

Market Analysis and Evaluation of the Nutritional Quality of Fodder Grown in Urban and Peri-Urban Areas of Niamey, Niger

[1]Salou Issaka Seybou, [2]Fernàndez Rebollo Pilar, [2]José Ramon Leal Murillo, [1]Mahaman Malam Mouctari Ousseini, [1]Barage Moussa and [1]Chaibou Mahamadou

[1]Department of Productions Animales, Université Abdou Moumouni, Niger
[2]Department of Forestry Engineering, University of Cordoba, Spain

Article history
Received: 14-04-2025
Revised: 04-06-2025
Accepted: 16-06-2025

Corresponding Author:
Salou Issaka Seybou
Department of Productions Animales, Université Abdou Moumouni, Niger
E-mail: seybousal@gmail.com

Abstract: The development of domestic ruminant livestock farming is hampered by the lack of forage, which is largely dependent on natural pastures and crop residues. In the outskirts of major cities, access to grazing land is becoming increasingly restricted. To meet the growing demand for fodder, feed markets are emerging in urban centers. The main aim of this one-year, three-season study is to analyze the market and nutritional quality of fodder grown in Niamey. A total of 150 forage sellers were contacted, 75 of whom were listed for the survey. A bromatological analysis of 12 forage samples was carried out, and an Analysis of Variance (ANOVA) was performed using SPSS version 26 software. The results showed that marketed fodder comes from fields, irrigated perimeters, fallow land, pastoral enclaves, farms and riverbanks. The value chain mobilizes a variety of actors, including producers, sellers and breeders. Chemical analysis of cultivated forages has shown that brachiaria (*Brachiaria mutica*) and local bourgou (*Echinochloa stagnina* (L.) Retz. Beauv.) have crude protein levels of 15.76 and 13.89% respectively, well above the critical crude protein utilization threshold of 7%. These forages stand out for their good nutritional balance. What's more, the marketing of forages is a job-creating, income-generating activity.

Keywords: Nutritional Value, Forage, Urban, Niger

Introduction

In the Sahel, livestock farming is a key pillar of national economies and makes a significant contribution to the food security of rural households (Cisse, 2015) In Niger livestock farming is the second most important economic activity after agriculture, and thus plays a key role in the country's economy, with total livestock numbers estimated at 50.5 million head (Ministry of Agriculture and Livestock, 2020). It is practised by 87% of the population and contributes 11% to national GDP and 25% to agricultural GDP (Rhissa, 2010). Despite its undeniable potential, ruminant livestock farming still faces constraints, the main ones being the degradation of pastures under the effect of anthropic and climatic pressure, rainfall deficits leading to recurrent food shortages for animals, and demographic pressure, which promotes competition between agricultural crops and pastures for land occupation (Moustapha *et al.*, 2018). These constraints are particularly critical in areas on the outskirts of major cities, where natural and cultivated pastures are becoming increasingly scarce. Livestock farmers rely mainly on food sources such as crop residues and rough hay, which represent the bulk of fodder used, often of poor nutritional quality (Ousseini *et al.*, 2017). Faced with this fact, which considerably limits the productivity of livestock, other alternatives must be sought to feed the animals adequately in order to reduce forage food deficits (Dan Gomma *et al.*, 2017). For example, the challenge of limited or no direct access to natural or cultivated pastures in urban settings has led to the emergence of fodder supply as a way to improve animal nutrition there (Kiemizanga *et al.*, 2011). However, in the long term, this strategy may compromise the food security of local livestock, as they depend on external forage. In this context, one of the main questions is to know the nutritional value of cultivated forages and to assess their contribution to the food security of urban domestic ruminants. The main

objective of this work is to analyze the forage market and the nutritional quality of forages grown in Niamey, in order to help livestock farmers choose forages adapted to the specific nutritional needs of their animals. To do this, we (i) Identified the main fodder crops sold in the urban and peri-urban areas of Niamey, (ii) Analysed their nutritional quality and (iii) Determined the socio-economic characteristics of fodder sellers. This research aims to provide essential data to institutions in charge of livestock development, researchers and agricultural producers, in order to promote better management of forage resources and improved livestock rearing practices.

Materials and Methods

Study Area

The study was carried out in the Niamey region, encompassing both the urban area, corresponding to the large conurbation subdivided into five communes, and the peri-urban area, comprising villages located between 5 and 15 km around the city and administratively attached to the communes (Niger, 2015) Fig. 1. This region, located in western Niger, extends between the geographical coordinates 2°10' and 2°14' East longitude and 13°33' and 13°36' North latitude (Niger, 2015). It covers an area of 55,227 hectares, characterized by a tropical Sudano-Sahelian climate with an average annual temperature of 37°C peaks reaching 44°C in April and minimums of 16°C in January (NMD, 2022) Fig. 2. Average annual rainfall is 563.3 mm distributed mainly between the June and September (Niger, 2015). Natural and cultivated vegetation, influenced by the semi-arid climate and human activities, varies by zone. In the urban environment around the River Niger, the most common woody and forage crops are neem (*Azadirachta indica* A. Juss.), mango (*Mangifera indica* L.,), lemon (*Citrus reticulata Blanco,*), as well as the forage grasses bourgou (*Echinochloa stagnina* (L.) Retz. Beauv.), and maralfalfa (Pennisetum purpureum, Schumach), selected for their fruit production, shade, drought tolerance, low maintenance requirements and biomass production. In peri-urban areas, the dominant species are gao ((Faidherbia alibida) (Delile) A. Chev.,), desert date palm (*Balanites aegyptiaca* Delile), jujube (*Ziziphus mauritiana* Lam.), as well as seasonal grasses and legumes (e.g. Alysicarpus ovalifolius (Schumach. & Thonn.) J. Léonard). Agriculture is an essential activity for a large part of the local population, as is livestock breeding. Niamey's livestock population in 2014 was 253,425 head, all species combined, equivalent to 95,703 TLU. This livestock is made up of various species, including cattle, sheep, goats, camels, asines and horses (Dan Gomma *et al*., 2017). Source: (Fig. 1) (Salou, 2024) Source: (Fig. 2) Niger Meteorological Department, 2022.

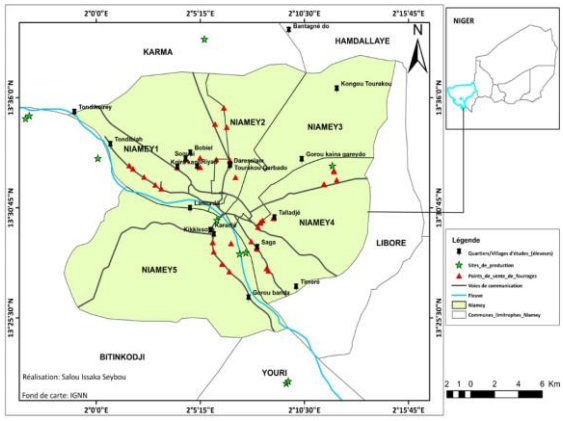

Fig. 1: Location of study area

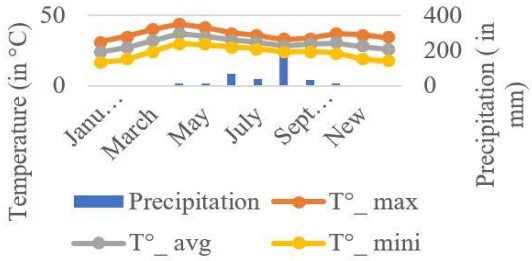

Fig. 2: Temperature and precipitation trends in 2022

Methodology

Surveys

The study began with a pre-survey to identify the main players involved in fodder marketing. These actors are spread over different sales outlets, generally located along the main arteries of the city of Niamey (Photo 1). These sales outlets were surveyed and visited during three seasons: rainy, cold dry and hot dry, as some sellers operate on a seasonal basis. In all, one hundred and fifty (150) fodder sellers were counted across the various outlets, from which 75 sellers were selected through a random sample. This sample, representing 50% of the population counted, was deemed sufficient to guarantee the reliability of the results. Information was collected using a structured questionnaire covering various aspects such as the socio-economic characteristics of the sellers, the types of fodder marketed, their origin, fodder prices and gross income.

(A) (B)

Photo 1: Green fodder for sale (A) and Interposing crop residues for sale (B)

Forage Sampling

In August, samples (Photo 2A) were taken from Niamey's three main forage crops: maralfalfa (*Pennisetum purpureum Schumach*.), bourgou (*Echinochloa stagnina (L.) Retz. Beauv*.) and brachiaria (*Brachiaria mutica (Forssk.) Stapf*.). This month is generally favorable for sampling vegetation, as it is in full growth, making it easier to assess the potential nutritional quality of the forages (Moussa Saley, 2025. In this study, three varieties of *Pennisetum purpureum* were used: a first-cut variety (S1) and a second-cut variety (S2) from Senegal, followed by those from Mauritania (MM) and Burkina Faso (MB). For the latter two varieties, a sub-sample was subdivided into leaves, stems and composite (leaves and stems). For *Echinochloa stagnina*, three varieties were sampled: a local variety (L) and two varieties from Mali (M1 and M2). Finally, a single sample was taken for *Brachiaria mutica*, representing the local variety commonly grown. In all, 12 forage samples were taken. The samples were pre-dried in the shade for 5 days to reduce water content without the risk of nutrient degradation due to direct exposure to sunlight. They were then placed in an oven at 60°C for 72 hours (Photo 2B). Finally, the dried samples were ground and passed through a 1 mm diameter sieve. Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), Mineral Matter (MM), Crude Protein (CP) and enzymatic digestibility of organic matter (EDOM) were determined using Near-Infrared (NIR) spectroscopy. A LabSpec-5000 portable spectrometer (350-2500 nm; ASD Inc., Boulder, Colorado, USA), using IndicoPro 6.0 spectra acquisition software (ASD Inc., Boulder, Colorado, USA), was used for this purpose (Photo 3A). Four replicates of each sample were scanned, and averaged to obtain the final spectrum. Bromatological values were determined using previously calibrated prediction equations (INRA, 2019). Mineral Matter (MM) was determined by calcining the sample (three replicates) in an oven at 550ºC. Crude Protein Concentration (CP) was calculated from N concentration, determined by combustion using the Dumas method (model LECO CNS928, LECO Corporation, MI, USA), multiplied by 6.25. Organic Matter Digestibility (OMd), Voluntary Dry Matter Intake (VDMI) and gross, digestible and metabolizable energy were calculated according to equations proposed by INRA (2019). Finally, P, K, Mg and Ca concentrations were analyzed at the University of Córdoba's soil science unit. K, Ca and Mg were measured with a Perkin Elmer Analyst 200 atomic absorption spectrometer (PerkinElmer, Inc., Waltham, MA, USA) (Photo 3B). P was analyzed with a BioTek PowerWave HT Microplate absorbance reader (BioTek® Instruments, Inc., Winooski, VT, USA).

The specific equations used to calculate:

Digestibility of Organic Matter (DMO)

DMO (%): 29.7+0.630*EDDM

Voluntary dry matter intake (VDMI)

VDMI(Gdm/KgBW0.75)

:(16+0.806*OMd+0.115*CP+0.686*DM-1.7)

Gross energy

GE (Kcal/Kg OM): 4.531+ 1.735*CP -71

Digestible energy

DE (Kcal/Kg DM): GE*0.01*Ed

Metabolisable energy

ME (Kcal/Kg DM): DE-ECH4-EU

(A) (B)

Photo 2: Sample collection (A) and oven drying (B)

(A) (B)

Photo 3: LabSpec-5000 portable spectrometer (A) and Atomic Absorption Spectrometer (B)

Statistical Analysis

The data collected were entered and coded in a template designed in Excel, which was also used to produce the tables and figures. Statistical analyses were then carried out using SPSS software, version 26. Firstly, a descriptive analysis was carried out to calculate the frequencies, mean values and standard deviations of the various survey variables. Factors influencing marketed forage prices were analyzed using ANOVA, and means were compared using Duncan's test at the 5% threshold.

Results

Socio-Professional Characteristics of Forage Sellers in Niamey

Table 1 shows the main socio-professional characteristics of forage sellers in the city of Niamey. The results show that in urban areas, the majority of sellers are men (77.3%), mainly adults (45.3%) in the

20-39 age bracket. They are mostly of Zarmas ethnicity (49.3%) and single (37.3%), with primary education (25.3%). Average tenure is 8.14±2.3 years. In peri-urban areas, vendors are more diversified, with women (2.6%) and a high proportion of married people (21.3%). While urban vendors are predominantly shopkeepers, the main activity of peri-urban vendors is farming (16%). The Zarmas are still the majority ethnic group (12%). In both zones, there is a predominance of uneducated people.

Table 1: Socio-professional characteristics of salespeople

Variables	Terms and conditions	Urban zone		Suburban area	
		N	%	N	%
Age	0-19 years	7	9,3	0	0,0
	20-39 years	34	45,3	8	10,7
	40-59 years	17	22,7	9	12,0
	Total	58	77,3	17	22,7
Gender	Mal	58	77,3	15	20
	Femal	0	0	2	2,6
	Total	58	77,3	17	22,7
Ethnic group	Haoussa	14	18,7	4	5,3
	Zarma	37	49,3	9	12
	Peulh	4	5,3	4	5,3
	Gourmantch	3	4	0	0
	Total	58	77,3	17	22,7
Marital status	Married	27	36	16	21,3
	Divorced	3	4	1	1,3
	Single	28	37,3	0	0
	Total	58	77,3	17	22,7
Level of education	No	17	22,7	6	8
	Literate/Arabic	12	16	2	2,7
	Primar	19	25,3	5	6,6
	Secondary	8	10,6	2	2,7
	Superior	2	2,7	2	2,7
	Total	58	77,3	17	22,7
Religion	Muslim	58	77,3	14	18,7
	Christian	0	0	3	4
	Total	58	77,3	17	22,7
Main activity	Retailer	50	66,6	12	16
	Breeding	0	0	0	0
	Agriculture	8	10,7	3	4
	School	0	0	2	2,7
	Total	58	77,3	17	22,7
Status of sales representatives	Wholesalers	28	37,3	11	14,7
	Semi-wholesalers	8	10,7	6	8
	Retailers	22	29,3	0	0
	Total	58	77,3	17	22,7
Seniority/year		8,14±2,3	-	6,4±2,3	-

N = Number; % = Percentage

Origin of Fodder Marketed in Urban and Peri-Urban Areas of Niamey

Figure 3 illustrates the distribution of different forage supply sources in Niamey. The results show that the majority of supplies come from Tillaberi (25%), followed by imports from Nigeria (18%), the Maradi region (16%) and Tahoua (12%). Local plots and the river contribute 10 and 12% respectively. Finally, farms, with a contribution of 7%, indicate a low use of this source in the overall supply.

Forage prices and determining factors. The prices of marketed forages are shown in Table 2, according to the season of sale. Among the forage types analyzed, Zornia glochidiata straw showed the lowest price, at 56 FCFA/kg in the rainy season, while fresh bourgou, recognized for its nutritional value, reached 269 FCFA/kg, particularly in the hot dry season, due to its scarcity and high demand. ANOVA analysis of the factors influencing marketed forage prices reveals that season of the year (with marked increases during periods of scarcity, particularly in the dry and hot seasons), forage type (based on its characteristics) and origin have a significant effect on prices per kilogram ($p<0.001$). On the other hand, neither the place of sale nor the status of the sellers had a significant impact on prices ($p>0.05$).

Table 2: Average price (FCFA/kg) of marketed forages according to season

Types of forages	Seasons of the year 2023-2024		
	RS	CDS	HDS
Bourgou *Echinochloa stagnina* (L.) Retz. Beauv,	95±35,46	156±68,21	269±70,9
Rice straw Oryza sativa L.,	117±25,82	142±37,64	225±27,39
Peanut hay Arachis hypogea L.,	79±14,5	96±25,74	155±32,51
Cowpea stover Vigna unguiculata (L.)	89±18,55	115±28,81	183±25,2
Goa leaves (Faidherbia alibida) (Delile) A. Chev,	113±23,15	126±37,01	175±37,80
Soybean leaves Glycine max (L.)	106±17,68	126±30,21	181±25,8
Cowpea pod Vigna unguiculata (L.)	104±15,06	130±17,73	236±54,9
Alysicarpus ovalifolius (Schumach. & Thonn.) J. Léonard	103±29,27	152±42,62	ND
Zornia glochidiata Rchb. ex DC.	56±7,35	141±37,64	ND
Commelina forskalaei Vahl,	69±15,17	109±52,96	ND
Bush straw	77±7,53	114±0,07	ND

RS: Rainy season; CDS: Cold dry season; HDS: Hot dry season; ND: Not determined

Table 3: Average gross revenue from marketed fodder by season and month (FCFA)

Types of forages	Seasons of the year 2023-2024		
	R S	CDS	HDS
Bourgou *Echinochloa stagnina (L.) Retz. Beauv,*	145625±14745	133125±16677	211875±42923
Rice straw *Oryza sativa L.,*	95833±30727	120000±35777	146667±49666
Peanut hay *Arachis* hypogea L.,	80000±28284	95000±30237	113125±29391
Cowpea stover Vigna *unguiculata (L.)*	98333±38687	110000±34059	130000±36332
Goa leaves (*Faidherbia alibida)* (Delile) A. Chev,	78125±27508	87500±25495	106250±29246
Soybean leaves *Glycine max* (L.)	81250±27484	93750±27223	103750±27223
Cowpea pod *Vigna unguiculata (L.)*	117500±20530	156875±13346	178750±36031
Alysicarpus ovalifolius (Schumach. & Thonn.) J. Léonard	58333±6831	70000±10954	ND
Zornia glochidiata Rchb. ex DC.	40833±6646	55000±8367	ND
Commelina forskalaei Vahl,	51000±12440	64000±11402	ND
Bush straw	58334±11690	71667±11690	ND

RS: Rainy Season; CDS: Cold Dry Season; HDS: Hot Dry Season; ND: Not Determined

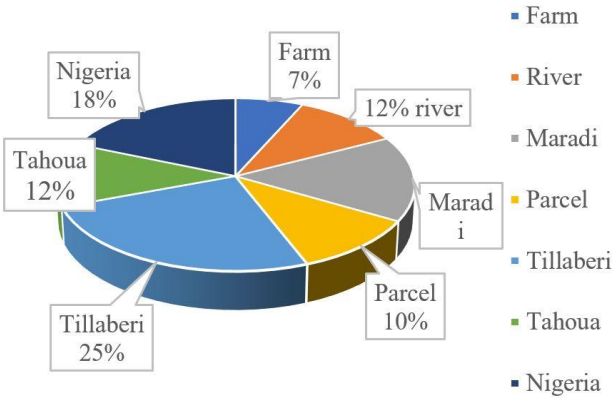

Fig. 3: Contribution of localities to Niamey's fodder supply

Average Monthly Gross Income from Forage Sales by Season

Table 3 shows average monthly gross revenues from the sale of various forages, broken down by three seasons. The standard deviation associated with each figure reflects the variability of revenues, indicating possible fluctuations according to forage availability and demand. In general, revenues are highest during the hot dry season, especially for forages such as bourgou, cowpea hulls and rice straw, which generate revenues of 211,875 FCFA, 178,750 FCFA and 146,667 FCFA respectively. Conversely, forages such as *Commelina forskalaei*, *Alysicarpus ovalifolius* and *Zornia glochidiata* are less profitable and only available at certain times of the year.

Chemical Composition of the Main Types of Cultivated Forage

The analysis in Table 4 shows the chemical composition of cultivated forages. Brachiaria stands out for its good nutritional balance, characterized by low fiber content (NDF: 60.51 and ADF: 36.63%), high crude protein content (15.76%), high mineral content (13.51%) and high ethereal extract (2.2%). Local bourgou has a low fiber content (NDF: 69.94, ADF: 36.12%) and a high crude protein content (CP: 13.89%). In contrast, bourgou from Mali (M1 and M2) has high fiber content (NDF: 83.32-84.79, ADF: 40.75-41.19%) and low protein content (CP: 3.91-4.11%). Maralfalfa from Senegal 1st cut (S1) has the highest fiber content (NDF: 82.27, ADF: 44.46%) and the lowest protein content (CP: 2.55%) MM: Mineral matter; CP: Crude protein; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; dMO: Digestibility of organic matter; EE: Ethereal extract.

Chemical Composition and C/N Ratio of the Main Cultivated Forages

Analysis Table 5 of mineral elements shows that brachiaria contains the highest levels of Ca (0.62%), Mg

(1.16%) and S (0.35%), while second-cut maralfalfa from Senegal is the richest in P (0.45%) and K (2.54%). Local bourgou (19.28) and brachiaria (16.61) have the lowest C/N ratios, which may favour their digestibility by ruminants, whereas bourgou from Mali 2 (68.58) and first-cut maralfalfa from Senegal (109.71) have higher C/N ratios and are therefore unfavourable for digestibility.

Nutritional Quality of the Main Types of Forage Grown

Table 6 shows that local bourgou and brachiaria stand out for their high values for all nutritional parameters. These forages have the highest digestibility (EDOM 57.20 and 58.01% and OMd 65.74 and 66.25% respectively). They are also rich in Gross Energy (GE), with values of 4484.09 Kcal/kg OM for local bourgou and 4487.34 Kcal/kg OM for brachiaria. In contrast, certain types of maralfalfa from Senegal (first and second cuts) have low digestibility values (EDOM 25.28 and 47.07%, OMd 45.62% and 59.35 respectively) and gross energy (4464.42 58 Kcal/kg OM and 4476.58 Kcal/kg OM).

EDOM: Enzymatic Digestibility of Organic Matter; dOM: Digestibility of Organic Matter; VDMI: Voluntary Dry Matter Ingestion; DE: Digestible Energy; GE: Gross Energy; ME: Metabolizable Energy.

Table 4: Chemical composition of the main cultivated forages

Species	Cultivar	MM (%)	NDF (%)	ADF (%)	CP (%)	EE (%)
Echinochloa	Bourgou L	11,10	69,94	36,12	13,89	2,1
stagnina	Bourgou M_1	11,41	83,32	40,75	4,11	2,0
	Bourgou M_2	11,90	84,79	41,19	3,91	2,0
Pennisetum	Maralfalfa MB	6,65	80,89	41,25	8,19	2,1
purpureum	Maralfalfa MM	9,23	73,53	40,10	11,05	2,1
	Maralfalfa S_1	8,95	82,27	44,46	2,55	2,0
	Maralfalfa S_2	14,58	70,06	36,54	9,56	2,1
Brachiaria mutica	Brachiaria	13,51	60,51	36,63	15,76	2,2

Table 5: Mineral content and C/N ratio of main cultivated forages

Species	Cultivar	Ca (%)	P (%)	K (%)	Mg (%)	S (%)	C/N
Echinochloa	Bourgou L	0,37	0,13	2,46	0,26	0,25	19,28
stagnina	Bourgou M_1	0,38	0,20	1,92	0,2	0,29	65,47
	Bourgou M_2	0,37	0,20	1,98	0,19	0,29	68,58
Pennisetum	Maralfalfa MB	0,27	0,11	1,89	0,21	0,11	35,28
purpureum	Maralfalfa MM	0,31	0,10	1,15	1,06	0,11	24,22
	Maralfalfa S_1	0,31	0,27	1,79	0,17	0,13	109,71
	Maralfalfa S_2	0,40	0,45	2,54	0,24	0,11	27,37
Brachiaria mutica	Brachiaria	0,62	0,19	2,12	1,16	0,35	16,61

Table 6: Nutritive values of the main forages grown in urban and peri-urban areas of Niamey

Species	Cultivar	EDOM (%)	OMd (%)	VDMI (gMS/ $KgBW^{0.75}$)	GE (Kcal/Kg OM)	DE (Kcal/Kg DM)	ME (Kcal/K g DM)
Echinochloa	Bourgou L	57,20	65,74	103,38	4484,09	2817,89	2733,04
stagnina	Bourgou M_1	38,34	53,85	92,30	4467,12	2299,17	2217,44
	Bourgou M_2	37,16	53,11	91,57	4466,79	2267,22	2185,43
Pennisetum	Maralfalfa B	38,67	54,06	93,32	4474,22	2311,72	2226,51
purpureum	Maralfalfa M	44,55	57,77	95,76	4479,17	2473,26	2386,96
	Maralfalfa S_1	25,28	45,62	85,29	4464,42	1946,22	1862,61
	Maralfalfa S_2	47,07	59,35	97,25	4476,58	2539,60	2456,34
Brachiaria mutica	Brachiaria	58,01	66,25	103,05	4487,34	2841,76	2755,63

Nutritional Quality of Maralfalfa Leaves and Stems

The NDF content of MB and MM maralfalfa stems was 84.89 and 83.9% respectively, while ADF content was 42.7% for MB and 39.2% for MM. In general, the stems of both types of maralfalfa had higher levels of NDF and ADF than the leaves. Leaves, on the other hand, stand out for their high levels of mineral matter (10.92% for MB and 14.47% for MM) and crude protein (11.95% for MB and 14.69% for MM), confirming their nutritional richness compared with stems Fig. 4.

Mineral Composition of Maralfalfa Leaves and Stems

Figure 5 shows the mineral contents and C/N ratios in the leaves and stems of the two maralfalfa varieties. In general, mineral concentration in leaves is higher than in stems, except for K in Mauritanian maralfalfa and Mg in the Burkinabe variety, where values are similar in both parts of the plant. The leaves of Burkina Faso maralfalfa have the highest potassium (1.9%) and calcium (0.44%) contents, while those of Mauritania maralfalfa are richer in

magnesium (0.73%), phosphorus (0.16%) and sulfur (0.17%). Moreover, the stalks have a particularly high carbon/nitrogen (C/N) ratio, reaching 65.77% for maralfalfa from Burkina Faso and 43.28% for that from Mauritania.

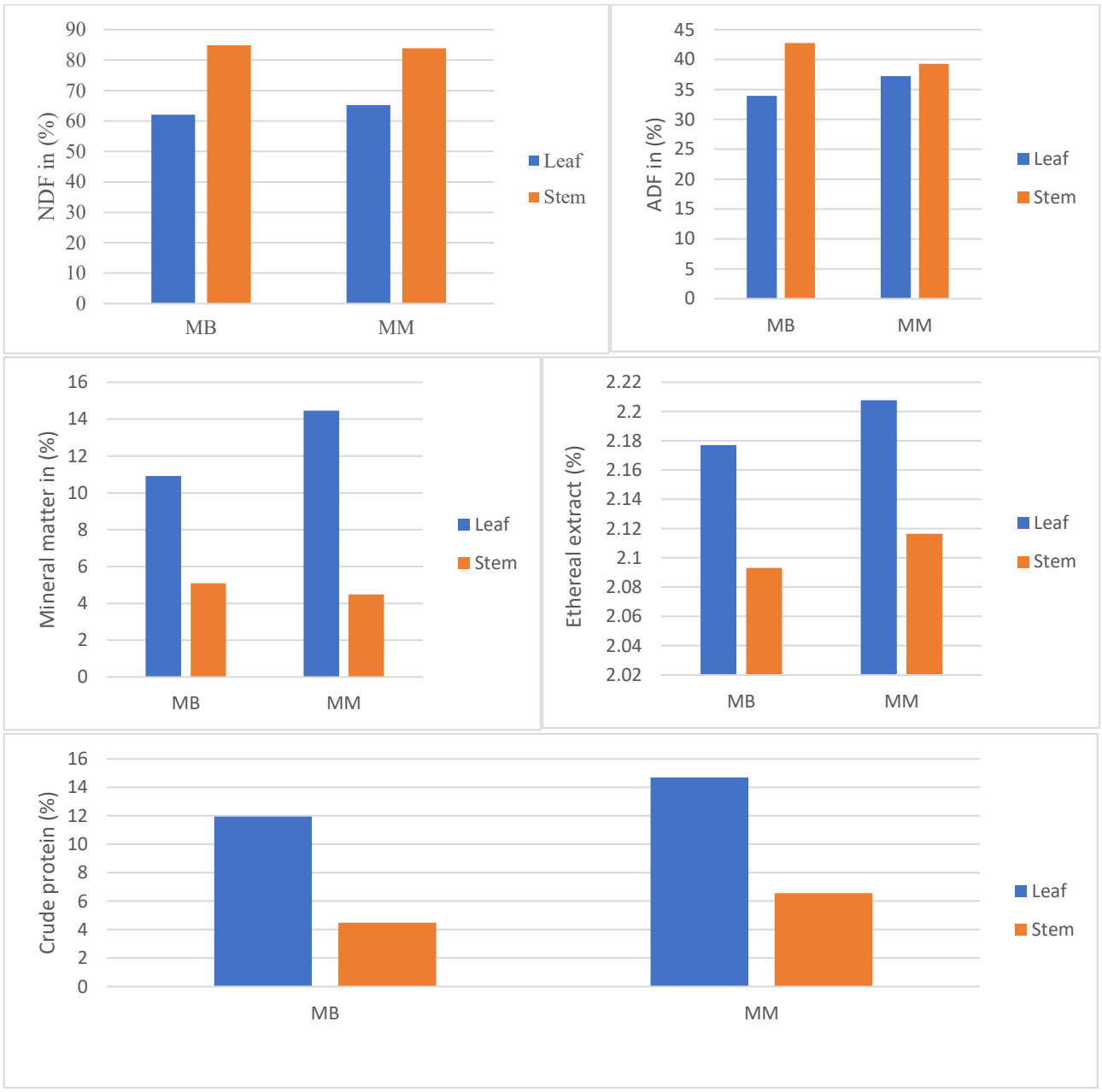

Fig. 4: NDF, ADF, MM, EE and PB content of maralfalfa leaves and stems from Burkina Faso and Mauritania

MB: Maralfalfa from Burkina; MM: Maralfalfa from Mauritania.

Nutritional Quality of Different Maralfalfa Parts

Analysis of the results shows a comparison of nutritional quality between the leaves and stems of two maralfalfa varieties (Maralfalfa B and Maralfalfa M). For Maralfalfa B, organic matter digestibility (dOM) was 65.80% for leaves, compared with 48.86% for stems. Maralfalfa M, however, has values of 63.10% for leaves and 53.85% for stems. For example, the stems of the Mauritanian maralfalfa variety appear to have a higher nutritional value than those from Burkina, with less difference between stems and leaves in the former

variety (MB). The intake is similar for the leaf fraction of both varieties, but the voluntary intake of ruminants for the stems of the Mauritanian variety is higher Table 7 EDOM: Enzymatic Digestibility of Organic Matter; dOM: Digestibility of Organic Matter; VDMI: Voluntary Dry Matter Ingestion; DE: Digestible Energy; GE: Gross Energy; ME: Metabolizable Energy; Maralfalfa B: Maralfalfa from Burkina Faso; Maralfalfa M: Maralfalfa from Mauritania.

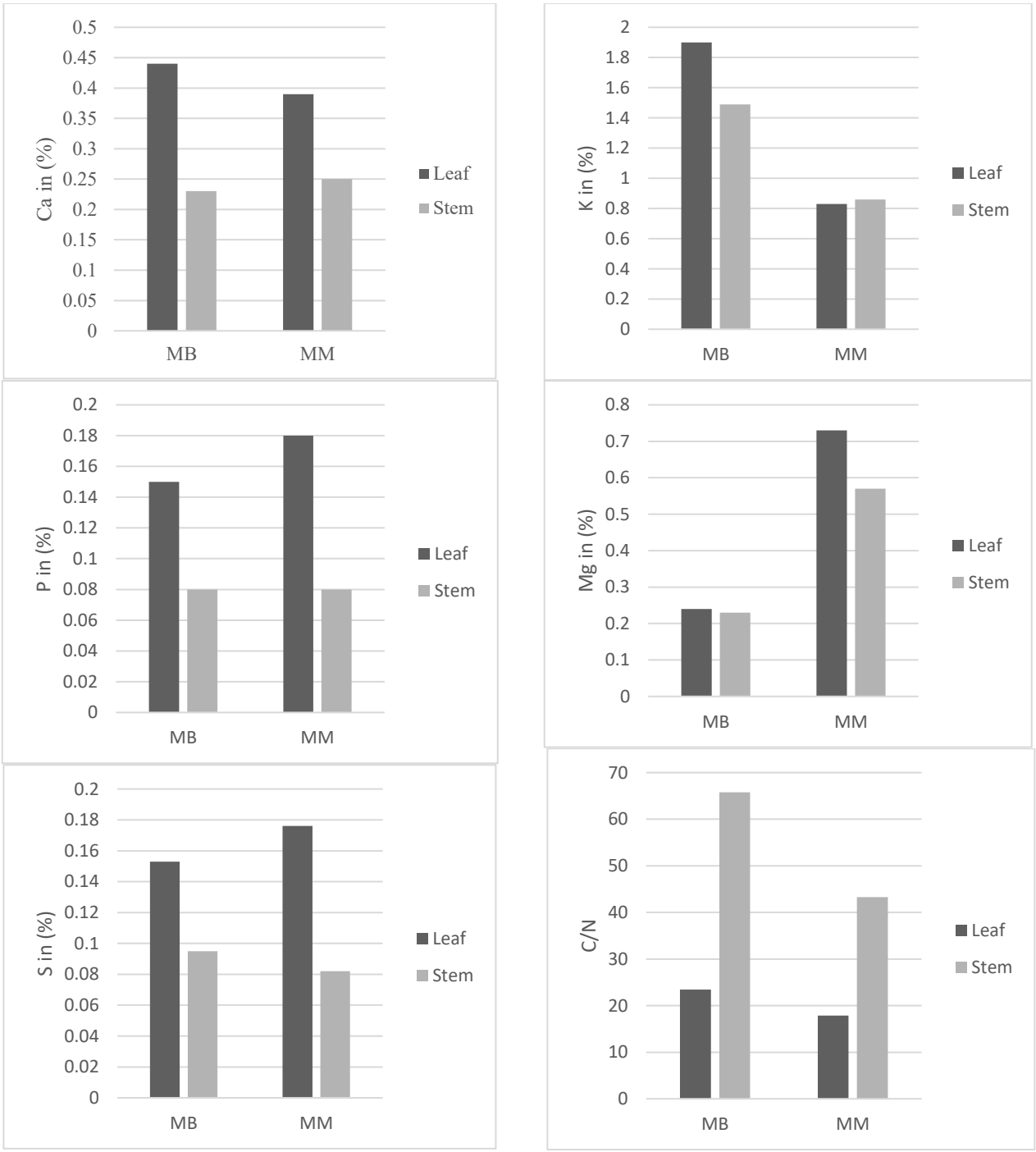

Fig. 5: Composition of mineral elements Ca, P, K, Mg, S and C/N ratio in maralfalfa leaves and stems from Burkina Faso (MB) and Mauritania (MM)

Table 7: Energy values and digestibilities of maralfalfa leaves and stems

	Maralfalfa. B		Maralfalfa. M	
	Leaf	Stem	Leaf	Stem
EDOM (%)	57,26	30,41	53,01	38,33
OMd (%)	65,80	48,86	63,10	53,85
VDMI (g MS/KgBW$^{0.75}$)	102,21	88,57	100,36	92,75
GE (Kcal/Kg OM)	4480,73	4467,79	4485,49	4471,45
DE (Kcal/Kg OM)	2818,50	2085,85	2705,54	2301,21
ME (Kcal/Kg OM)	2734,18	2001,39	2619,41	2216,41

Discussion

The study shows that men are the main practitioners of fodder sales (77.3%). This result is similar to that obtained by Sanon *et al*. (2018). According to the latter, fodder sales are an activity practiced by men (94%) in a study conducted on the analysis of the structure and functioning of fodder markets in Burkina Faso. This can be explained by the arduous nature of the work and the fact that it is more popular with men. Analysis of the results of this study shows that the majority of sellers (45.3%) in urban areas are aged between 20 and 39. These results differ from those of (Lawal *et al*., 2017), who found that over 45% of the actors interviewed in their study of crop residues in Niamey were aged between 40 and 60. This difference could be explained by the fact that the activity in question is more appreciated by young adults. The results show that Tillabéri is the main source of supply, with 25%. These results are similar to those obtained by (Abdou *et al*., 2017a), who showed that Simiri alone contributes 25% of Niamey's supply of various forages in a study conducted on the marketing and nutritional value of forages in Niger. This can be explained by the fact that producers in these localities grow cowpeas and groundnuts for the sale of tops. This study shows that the factors influencing the prices of fodder sold in urban and peri-urban areas of Niamey are the season, the nature of the fodder and its origin. These results are similar to those obtained by Ousseini (2017); Manzo (2009); Maman (2014). According to the latter, forage prices vary according to location and period. These results show that *Zornia glochidiata* has the lowest price (56 F CFA/kg) in the rainy season, while fresh bourgou, appreciated for its nutritional value, reaches a high price of 269 F CFA/kg during the hot dry season due to its scarcity and high demand. However, these results differ from those of (Abdou *et al.,* 2017b), according to whom cowpea pod is the most expensive (263 F CFA/kg) in a study of yields and economic profitability of crop production in Djirataoua (Maradi, Niger Republic). This difference could be explained by the local specificities of fodder resources and the food or economic priorities of the communities concerned, thus influencing price variations according to the types of fodder available and seasonal demand. According to Dan Gomma *et al.* (2000), fodder prices can increase by 300 to 500% during the Tabaski festivities or the lean season. This price fluctuation is explained by the law of supply and demand linked to the lean season, which extends between seasons. The results of chemical analysis show that bourgou from Mali and first-cut maralfalfa from Senegal have a relatively low total nitrogen content, ranging from 3.91 to 2.55%, well below the critical threshold for crude protein utilization, estimated at 7% (Van Soest, 1982). Below this threshold, rumen microflora activity in domestic ruminants is reduced. Brachiaria and local bourgou are above the estimated threshold, at 15.76 and 13.89% respectively. These results differ from those obtained by Sanfo *et al*. (2023) in Burkina Faso, according to whom the PB contents of maize and cowpea forages were 7.9% and 18.7% respectively. In terms of quality, forages such as brachiaria and local bourgou appear to be the best. They have the highest protein values and the lowest ADF (Detergent Fibre Acid), leading to better digestibility of organic matter and higher metabolizable energy. In addition, the voluntary intake of by ruminants is higher, increasing their nutritional value as feed. This could be linked to the adaptation of local varieties to Niamey's climate, unlike foreign varieties, which seem less well adapted. First-cut maralfalfa from Senegal has the highest fiber content (NDF: 82.27%, ADF: 44.46%). ADF fibers are generally linked to the digestibility and energy value of the forage; the more ADF fibers there are in the forage, the lower the digestibility and energy value. The data reveal that brachiaria is distinguished primarily by its richness in minerals such as calcium (0.62%), magnesium (1.16%) and sulfur (0.35%), making it a beneficial plant for feeding systems requiring a high intake of these elements. In contrast, the second cut of maralfalfa from Senegal has a higher concentration of phosphorus (0.45%) and potassium (2.54%), minerals essential for energy metabolism and water balance in animals. In terms of plant structure, maralfalfa stems (MB and MM) show high levels of fiber (NDF and ADF), at 84.89% and 83.9% respectively, indicating that they are richer in woody matter and less digestible. This suggests that stems can be a source of dry matter, but their limited digestibility could reduce their nutritional value for animals. Conversely, the

leaves of both types of maralfalfa are remarkably richer in crude protein (11.95% for MB and 14.69% for MM) and minerals (10.92 for MB and 14.47% for MM), making them particularly interesting for animal feed due to their high digestibility and nutritional contribution.

The differences observed between varieties of the same species could also be due to the fact that they were at different phenological stages at the time of sampling, which was nevertheless carried out on the same date. We know that protein content decreases with maturity, while NDF content increases. Moreover, the leaf, which has better bromatological values than the stem, may mean that the leaf/stem ratio also influences the overall quality of the forage.

Given the prevalence of misinformation about fodder quality in Niamey, the results of the study should be shared on social media platforms to improve public awareness and market transparency.

Conclusion

This study enabled us to gain a better understanding of the fodder marketed, gross revenues, the players involved, and the nutritional value of fodder grown in the urban and peri-urban areas of Niamey. The results show that this activity is mainly practised by men aged between 20 and 39, and constitutes an important source of income, enabling them to meet their needs. Niamey's fodder supply is based on crop residues, natural fodder and imports from Tillaberi, Maradi, Tahoua and Nigeria. However, these forages are often of poor nutritional quality. The most common forages and crop residues are cowpea tops, groundnut tops, rice straw, bush straw, cowpea pods and bourgou, the latter being the only cultivated forage. Although the availability of cultivated forages on the market remains limited, their nutritional quality is relatively good. Digestible crude protein content ranges from 2.55% to 15.76%, while mineral elements are characterized by high levels of calcium (0.62%), magnesium (1.16%), sulfur (0.35%), phosphorus (0.45%) and potassium (2.54%). These elements are essential for the growth and health of ruminants.

These forages stand out for their good nutritional balance. What's more, the marketing of forages is a job-creating, income-generating activity.

In view of the results, it would be interesting to promote the cultivation of brachiaria as well as the local variety bourgou. It would also be relevant to test the behavior of foreign varieties before introducing them into the fields, in order to assess their adaptation to climatic conditions and their bromatological value.

Suggested directions for future research: Extension of the study to a wider geographical area.

Further analysis of the economic factors affecting fodder marketing.

Acknowledgment

The authors would like to express their gratitude to the Regional Center of Excellence on Pastoral Productions (RCEPP) for facilitating the funding of this study. They would also like to thank all the forage producers in the urban and peri-urban area of Niamey for their availability and frank collaboration during the study.

Funding Information

This research was supported by Erasmus Plus through the University of Cordoba (Spain), which covered the cost of bromatological analyses.

Author's Contributions

Salou Issaka Seybou: Conceptualization, data collection (fieldwork), formal analysis, and original draft preparation.

Fernàndez Rebollo Pilar: Supervision (training and analysis at the Forest Engineering Laboratory, Cordoba, Spain), and critical review and revision of the manuscript.

José Ramon Leal Murillo: Performed various analyses and interpretation of the results.

Mahaman Malam Mouctari Ousseini: Assisted with the development of the study protocol, and provided critical review and revision of the manuscript.

Barage Moussa: Supervision, and provided significant assistance with the manuscript drafting and critical review and revision.

Chaibou Mahamadou: Supervision, assisted with the development of the study protocol, and provided critical review and revision of the manuscript.

Ethics

This article is original and has never been published before.

The author has also confirmed to all the authors involved in this study that they have read and accepted the content of this article and that there are no ethical issues.

References

Abdou, D. G., Chaibou, I., Maxime, B., & Eva, S. (2017a). Marketing and nutritional value of forages in urban centers in Niger: the case of the cities of Maradi and Niamey. *International Journal of Innovation and Applied Studies*, *21*(3), 508–521.

Abdou, M. M., Salissou, I., Abdou, D. G., Adama, S., & Germain Jerome, S. (2017b). Estimation of yields and economic profitability of production of three crops: sorghum, cowpea and cowpea in Djirataoua (Maradi - Republic of Niger). *Journal of Applied Biosciences*, *117*(1), 11642. https://doi.org/10.4314/jab.v117i1.1

Cisse, M. (2015). *Study of the palatability of woody forages and their influence on the weight evolution of sheep in Mali*.

Dan Gomma, A. D., Bareck, M. M., Salissou, I., Ayssiwede, S., Mahamadou, A., Siddo, S., Ibro, G., Baye, I., Mamann, M., Chaibou, I., Chaibou, M., Moutari, M., & Chanono, M. (2017). Technical and economic evaluation of multi-nutritional block feed formulas for sheep fattening in Niger. *Agronomie Africaine*, *29*(1), 1–11.

INRA. (2019). *INRA Feeding system for ruminants*.

Kiemizanga, F. S., Souleymane, N., Mathieu, O., Souleymane, O., & Chantal, K.-Z. (2011). Forage marketing in the urban area of Bobo-Dioulasso (Burkina Faso): market practices and economic profitability. *Cahiers Agricultures*, *20*(6), 487–493. https://doi.org/10.1684/agr.2011.0530

Lawal, M. A., Chaibou, M., Garba, M. M., Mani, M., & Gouro, A. S. (2017). Management and use of crop residues for animal feed in urban and peri-urban areas: the case of the urban community of Niamey. *Journal of Applied*, *115*, 11423–11433.

Maman, S. (2014). *Analysis of the fodder marketing system in the city of Niamey (Niger*.

Manzo, R. R. A. (2009). *Étude du flux de fourrage vert des zones périurbaines vers la ville de Niamey en saison pluvieuse. Mémoire Sciences Agronomiques, Faculté d'Agronomie*.

Moussa Saley, S., Mamadou Boulama, M. B., Fanta, O., Ali Hama, A. H., Mahamadou Amadou, G. M., Ali, Z., Abdou, N., Nassirou, S., Hanki, Y., Daou, M., Brah, S., & Adehossi, E. (2025). Étude de l'hépatite virale B chronique chez les patients suivis à l'hôpital national de Niamey. *Journal Africain Des Cas Cliniques et Revues*, *9*(1), 62–70. https://doi.org/10.70065/2591.jaccrafri.0111011301

Ministry of Agriculture and Livestock. (2020). *Statistics of the Livestock Sector*.

Moustapha, I. S., Ousseini, M. M. M., Inoussa, D., & Chaibou, M. (2018). Caractérisation technique des élevages des ruminants dans la ville de Niamey (Niger). *International Journal of Innovation and Applied Studies, 24*(4), 1718–1725.

Niger Meteorological Department. (2022). *Climatology of the year 2022 at Niamey-Aero - Infoclimat*.

Ousseini, M. M. M., Mahamadou, C., & Mamman, M. (2017). Practice and use of legume by-products in livestock feed in the urban community of Niamey: Case of cowpea (Vigna unguiculata) tops and pods. *Journal of Applied Biosciences*, *120*, 12006–12017. https://doi.org/10.35759/jabs.120.3

Ousseini, M. M. M., Mahamadou, C., & Mamman, M. (2017). Practice and use of legume by-products in livestock feed in the urban community of Niamey: Case of cowpea (Vigna unguiculata) tops and pods. *Journal of Applied Biosciences*, *120*, 12006–12017. https://doi.org/10.35759/jabs.120.3

Rhissa, Z. (2010). *Review of the livestock sector in Niger*.

Sanfo, A., Nouhoun, Z., Michel, K., Eric Aimé, K., Souleymane, S., & Kader, T. (2023). Forage conservation methods: nutritional qualities and performance of sheep in peasant fattening in Burkina Faso. *Revue Burkinabè de La Recherche*, *44*(1), 1011–6028.

Sanon, H. O., Some/Sanou, S., Obulbiga, M. F., Oubda, F. A., & Bamouni, I. (2018). Analyse de la structure et du fonctionnement de la filière fourrage dans les villes de Ouagadougou et Bobo-Dioulasso au Burkina Faso. *International Journal of Biological and Chemical Sciences*, *12*(3), 1247. https://doi.org/10.4314/ijbcs.v12i3.14

Van Soest, P. J. (1982). *Nutritional ecology of ruminant*.