

Price and quality of livestock feeds in suburban markets of West Africa's Sahel: Case study from Bamako, Mali

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Keywords

Livestock – Suburban agriculture – Feed – Price – Quality – Nutritive value – Commodity market – Sahel.

Summary

In West African Sahel cities, livestock husbandry such as smallholder dairy production and livestock (cattle, sheep and goat) fattening has become popular among livestock owners to meet food needs for the household, and for income generation. The increasing importance of urban and suburban agriculture, particularly livestock husbandry in the region, has led to a rapid increase in livestock populations in most of the cities. As a result of this increase and the associated growth in the demand for feeds, feed markets have sprung up in many cities and towns of West Africa's Sahel. A survey of livestock feed markets was conducted in five markets in Bamako, Mali. Prices of livestock feeds were monitored monthly from January to December 2010. In addition, feed samples were collected from the markets for laboratory analysis to determine their nutritional quality. Results showed that the prices of cowpea hay and groundnut haulm were consistently higher than those of other feeds throughout the year. The price of cowpea hay ranged from 367 FCFA/kg dry matter (DM) (1 USD \approx 500 FCFA) in October, i.e. immediately after harvest, to 667 FCFA/kg DM in August, i.e. in the wet season. Results also showed that there was no relationship between price and quality for all feed types. However, prices and quality of feeds differed significantly across seasons suggesting that the season was a major determinant for the price of livestock feeds in suburban areas of West Africa's Sahel.

INTRODUCTION

There has been a rapid growth in the urban population in West Africa as in most sub-Saharan African countries in the last four decades (27). According to an African Development Bank report (1), in 2010 the share of the African urban population was about 36% and was projected to increase to 50% and 60%, by 2030 and 2050, respectively. This rapid urbanization is associated with spatial concentration of people of different cultural and geographical origins, different educational and professional backgrounds, and diversified livelihood strategies. Thus, a large proportion of urban people have been involved in agricultural activities such as crop farming, livestock husbandry and vegetable production since the 1980s (21). The main drivers for this trend include declining

prospects of securing 'white collar' jobs with government ministries and agencies due to the Structural Adjustment Programs of the 1980s and 1990s, a generally low level of education among rural migrants, and the growing demand for food by the urban population (27). In Sahelian cities of West Africa, livestock husbandry such as smallholder dairy production and animal (cattle, sheep and goat) fattening has become widespread to meet household food needs and for income generation (12). Sheep fattening in suburban areas of West Africa's Sahel is increasingly becoming an important economic activity and has been mainly driven by the Tabaski, the Islamic festival of Eid-al-Kabir (5, 9, 16). It is particularly attractive to poor farmers including women because of its low initial investment, rapid turnover rate, social acceptance and easy market access. The main strategy is to fatten young, lean male sheep, born on the farm or, more often, purchased on the open market, over a two to three month period, each farmer fattening between one and five animals (5).

This has led to a rapid increase in the livestock population in most cities and large towns in the region (11). Mali's Government reports (8, 13) show that in Bamako the cattle population increased from 8,000 to 32,086 head from 1989 to 2012, whereas the sheep and goat populations during the same period increased from 5,000 to 80,686 head, i.e. an average annual growth rate of 6% and 13%,

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for cattle and small ruminants, respectively, compared to a national average annual growth rate of 4.4% and 7.4% for the same species, respectively. Livestock husbandry in urban and suburban areas of West Africa's Sahel is increasing because of the growing demand for livestock products and because well-to-do government officials and entrepreneurs, who are taking advantage of the prevailing accessibility of the market, are investing in livestock enterprises.

Feed is the main challenge to livestock husbandry in urban and suburban areas of West Africa's Sahel because of its scarcity during the dry season and the limited access to grazing areas (5, 11, 21). Most livestock keepers therefore depend on purchased feeds, often at high prices and influenced by seasonal variations. As a result of the increase in the livestock population and the associated growth in the demand for feeds, feed markets have sprung up in many cities and towns in the region. These livestock feed markets are usually located near livestock markets and they mainly sell crop residues, agricultural by-products such as cottonseed cake and cereal bran, concentrate feed from the small-scale feed industry, besides leaves from various shrubs and perennial sources. Information on the price and quality of feeds sold at these markets is important for optimization of livestock feeding strategies and enhancement of resource use efficiency in urban and suburban livestock production systems. The objective of the present study was to assess price variations for different feed types across seasons in suburban feed markets, and to determine whether there was a relationship between price and quality of livestock feeds.

■ MATERIALS AND METHODS

Study site

A survey was conducted in five livestock feed markets in Bamako in Mali, located in the areas of Lafiabougou, Sabalibougou, Faldje, Niamana and Boulkassoumbougou. These markets also sold livestock (cattle, sheep and goats). They were selected because of their relatively large size and year-round operations by feed sellers, and their three-kilometer minimum distance from one another. This ensured a sufficient number of sellers to select from for the survey which lasted for 12 months. All five markets were easily accessible by road. During the surveys, we did not collect data on the sales volume, turnover, origin of the feeds and characteristics of feed buyers but focused mainly on data collection of feed prices and quality.

Feed market survey

Prices of livestock feeds were monitored monthly in the five markets from January to December, 2010. For the monthly survey, five feed sellers in each market were randomly selected every month and interviewed by an enumerator in the local language. By interviewing five sellers per market we ensured that at least 20% of the total number of feed sellers in each market was sampled as there were about 20 feed sellers per market. Information on the price of every livestock feed was collected from the five feed sellers interviewed in each market. Information on the price of cereal grains (maize, millet, sorghum and rice) and legume grains (cowpea and groundnut) was also collected monthly from those among the five markets that sold food items. In addition, samples of all feeds present in the market were collected from one feed seller in each market for laboratory analysis to determine nutritional quality. In total, 294 feed samples were collected and processed for analysis. To establish the price of the feeds according to weight, particularly that of crop residues, we bought feeds from the sellers in each market every month, which were air dried then weighed. Apart from crop residues, the other feed types such as cereal bran, cottonseed

cake and concentrate feeds were usually sold at a predefined weight, mostly in bags of 50 kg and 100 kg.

Cost-benefit analysis of sheep fattening

To assess cost implications from livestock feed prices for sheep fattening in suburban areas of West Africa's Sahel, we formulated balanced rations based on two major feed types found in the markets, i.e. cowpea hay and concentrates for ruminants (Table I). The diet included either cowpea hay, as it is commonly used for sheep fattening in the region in combination with other feed ingredients (4), or a concentrate for sheep fattening because of its year-round availability and low price; it reduced the feeding cost, the price of cowpea hay being higher than that of the concentrates. Both cowpea-hay-based and concentrate-based diets contained 15% crude protein (on a dry matter [DM] basis) with fixed ingredients, i.e. bush hay (20% of the diet on DM basis) and cereal bran (10% of the diet on DM basis). The energy requirements of sheep were met in both diets according to AFRC recommendations (2). The cost implications of both formulated diets were assessed under four scenarios: (i) early dry season sales of sheep during an ordinary period, (ii) early dry season sales at the Tabaski, (iii) late dry season sales during an ordinary period, and (iv) late dry season sale at the Tabaski, when the sales price is always at least twice that of the ordinary period. The scenarios were tested in the early and late dry seasons when sheep fattening is usually carried out in the West African Sahel.

Laboratory analyses

Feed samples collected from the feed markets were analyzed for DM, ash content, nitrogen, fiber components (NDF and ADF), metabolizable energy (ME) and *in vitro* organic matter digestibility (IVOMD) using the near infrared reflectance spectroscopy (NIRS) technique after grinding (2 mm sieve). NIRS is an indirect analytical method based on the development of empirical models in which the concentration of a feed constituent is predicted from complex spectral data (6) as presented in Table II. Crude protein was estimated from nitrogen content (nitrogen x 6.25). Details on the NIRS prediction of sample values are presented in Table III.

Statistical analysis

Data analysis was performed with SAS (26) using the general linear model (GLM) procedures for variance and regression analyses. For analysis of the variance model, response (dependent) variables were price and nutritional quality (DM, ash, crude protein, fiber components, ME and IVOMD), whereas season was the independent variable. A calendar year was divided into three seasons: wet (June to September), early dry (October to January), and late dry (February to May). In the analysis, the season was considered as a binary categorical variable with a value of either 0 or 1. Unless otherwise specified, the level of significance was set at $p < 0.05$.

■ RESULTS

Price variations of different livestock feeds

Results showed that each feed seller sold between four and ten types of livestock feeds. The major feed types sold were cowpea hay, groundnut haulm, cottonseed cake, bush hay (consisting mainly of *Andropogon gayanus* and *Schizachyrium exile*), cereal bran (this included maize bran, millet bran, sorghum bran and rice bran), browse (shrub/tree fodder), and concentrates for ruminants (for maintenance and fattening from a local feed industry). The factory labels of the nutrient composition of the concentrate feeds read as follows: the maintenance feed contained 13% crude

Table I

Diet formulation for sheep fattening and costs based on cowpea hay or concentrates for ruminants¹

Feed	% in the diet	CP (% DM)	ME (MJ/day) ²	Cost of 100 kg DM diet (FCFA ³)
Early dry season - diet based on cowpea hay				
Bush hay	20	1.25	1.77	2,520
Cereal bran	10	11.88	1.26	1,350
Cowpea hay	52	15.75	7.06	22,204
Cottonseed cake	18	29.63	2.06	2,934
Total	100	15	12.15	29,008
Early dry season - diet based on concentrates for ruminants				
Bush hay	20	1.25	1.77	2,520
Cereal bran	10	11.88	1.26	1,350
Concentrate	63	18.19	8.66	10,395
Cottonseed cake	7	29.63	0.82	1,141
Total	100	15	12.51	15,406
Late dry season - diet based on cowpea hay				
Bush hay	20	1.63	1.83	3,420
Cereal bran	10	12.81	1.26	1,450
Cowpea hay	55	16.13	7.42	32,120
Cottonseed cake	15	30.13	1.80	2,490
Total	100	15	12.29	39,480
Late dry season - diet based on concentrates for ruminants				
Bush hay	20	1.63	1.83	3,420
Cereal bran	10	12.81	1.26	1,450
Concentrate	62	17.69	8.54	9,672
Cottonseed cake	8	30.13	0.96	1,328
Total	100	15	12.59	15,870

CP: crude protein; DM: dry matter; ME: metabolizable energy

¹ The diet for fattening ram contains 15% CP (DM basis) with fixed feeds: bush hay (20% of the diet on DM basis), cereal bran (10% of the diet on DM basis). To reach 15% CP (DM), the diet was balanced using cottonseed cake and cowpea hay or concentrates for ruminants. The daily feed offered for a 25-kg ram for fattening was estimated at 1.5 kg DM including allowance for left-over. The duration of fattening was 90 days. The energy requirement (ME, MJ/day) for a 25-kg ram for maintenance and growth (assumed average daily gain of 100 g/day) was estimated at 6 MJ/day (AFRC, 1993).

² ME supply from feed ingredients (MJ/day) was calculated as: MJ/kg DM in the feed (from Table II) multiplied by the proportion of the ingredient in the diet, multiplied by the daily offer (1.5 kg DM). For example, for bush hay in the early dry season, the ME supply/day was: (5.9 x 0.2) x 1.5 = 1.77 MJ/day

³ 1 USD ≈ 500 FCFA

protein, 4% ether extract, 12% crude fiber, 2% calcium, 0.5% phosphorus; and the fattening feed contained 15% contained crude protein, 5% ether extract, 6% crude fiber, 1.5% calcium, 0.85% phosphorus. We did not find any cereal straws (sorghum, millet or maize straws) throughout the year, perhaps because of the low demand and of their bulkiness which makes transport difficult.

The prices of cowpea hay and groundnut haulm were consistently higher than those of other feeds throughout the year (Table IV). The price of cowpea hay ranged from 367 FCFA/kg DM (1 USD ≈ 500 FCFA at time of study) in October immediately after harvest, to 667 FCFA/kg DM in August, i.e. in the wet season (Table IV). Generally, the price of crop residues (cowpea hay and groundnut haulm) corresponded with availability; it was highest during the wet season (June to September) and lowest immediately after harvest (October and November). The prices of agricultural by-products, such as cottonseed cake and cereal bran, and of concentrate feeds did not vary significantly across the seasons, suggesting adequate year round availability. The price of legume residues (cowpea hay and groundnut haulm) was almost twice that

of grain for most of the year except in the three months following harvest (October, November and December) (Figure 1). The prices of cowpea hay and groundnut haulm were on average 556 and 505 FCFA/kg DM, respectively, whereas the price of grain was 333 and 329 FCFA/kg DM, respectively. The price of cereal bran ranged between 131 and 146 FCFA/kg DM and was consistently lower than that of grain throughout the year (Figure 1).

Variations in nutritional quality of livestock feeds

In all seasons, cottonseed cake had a significantly ($p < 0.05$) higher crude protein content but significantly lower metabolizable energy than other feed types except bush hay (Table II). Bush hay had the lowest crude protein content and the highest fiber content (NDF and ADF) in all seasons compared to other feed types (Table II). The nutritional contents of cowpea hay and groundnut haulm were similar to that of concentrate feeds in terms of ash content, ME and IVOMD in all seasons. The crude protein content and IVOMD of cereal bran were significantly lower than that of cowpea hay and groundnut haulm (Table II), suggesting a lower nutritional quality

Table II

Nutritional quality (g/kg DM except for ME which is MJ/kg DM; mean \pm standard error) and price (FCFA¹/kg DM) of different feed types sold at five feed markets in Bamako, Mali, based on the season

Feed type	Ash	Crude Protein	NDF	ADF	ME	<i>in vitro</i> OMD	Price
Wet season² (June, July, August, September)							
Cowpea hay	96 \pm 6 ^a	217 \pm 13 ^b	485 \pm 25 ^b	341 \pm 23 ^b	9.5 \pm 0.1 ^a	685 \pm 11 ^a	658 \pm 9 ^a
Groundnut haulm	84 \pm 3 ^a	157 \pm 7 ^c	446 \pm 17 ^b	307 \pm 16 ^b	9.4 \pm 0.1 ^a	656 \pm 8 ^a	617 \pm 6 ^a
Cottonseed cake	61 \pm 3 ^b	292 \pm 11 ^a	467 \pm 13 ^b	303 \pm 19 ^b	7.6 \pm 0.2 ^b	567 \pm 13 ^b	169 \pm 5 ^c
Bush hay	41 \pm 9 ^c	36 \pm 6 ^d	834 \pm 37 ^a	556 \pm 23 ^a	6.1 \pm 0.5 ^c	399 \pm 32 ^c	196 \pm 8 ^b
Concentrate	91 \pm 2 ^a	191 \pm 9 ^b	389 \pm 12 ^c	139 \pm 21 ^d	9.4 \pm 0.1 ^a	665 \pm 9 ^a	161 \pm 4 ^c
Cereal bran	72 \pm 4 ^b	152 \pm 9 ^c	371 \pm 24 ^c	98 \pm 26 ^d	9.3 \pm 0.4 ^a	647 \pm 28 ^a	142 \pm 5 ^c
Browse	74 \pm 6 ^b	189 \pm 11 ^b	457 \pm 31 ^b	238 \pm 11 ^c	9.5 \pm 0.3 ^a	646 \pm 9 ^a	149 \pm 14 ^c
Early dry season² (October, November, December, January)							
Cowpea hay	83 \pm 3 ^a	157 \pm 10 ^b	452 \pm 17 ^c	299 \pm 13 ^b	9.1 \pm 0.2 ^a	642 \pm 11 ^a	427 \pm 14 ^a
Groundnut haulm	86 \pm 2 ^a	146 \pm 6 ^b	437 \pm 18 ^c	306 \pm 15 ^b	9.2 \pm 0.1 ^a	638 \pm 9 ^a	378 \pm 8 ^a
Cottonseed cake	58 \pm 1 ^b	296 \pm 7 ^a	490 \pm 10 ^c	322 \pm 11 ^b	7.5 \pm 0.2 ^b	565 \pm 12 ^b	162 \pm 4 ^b
Bush hay	27 \pm 3 ^c	13 \pm 1 ^d	863 \pm 7 ^a	552 \pm 15 ^a	5.9 \pm 0.3 ^c	392 \pm 16 ^c	126 \pm 5 ^c
Concentrate	88 \pm 2 ^a	182 \pm 9 ^b	397 \pm 10 ^c	124 \pm 20 ^c	9.2 \pm 0.1 ^a	651 \pm 10 ^a	165 \pm 5 ^b
Cereal bran	82 \pm 7 ^a	129 \pm 7 ^c	419 \pm 24 ^c	136 \pm 34 ^c	8.4 \pm 0.3 ^a	586 \pm 18 ^b	134 \pm 3 ^{bc}
Browse	46 \pm 14 ^b	155 \pm 11 ^b	549 \pm 39 ^b	289 \pm 14 ^b	8.6 \pm 0.1 ^a	585 \pm 9 ^b	101 \pm 6 ^c
Late dry season² (February, March, April, May)							
Cowpea hay	89 \pm 4 ^a	161 \pm 13 ^b	468 \pm 22 ^c	320 \pm 18 ^b	9.0 \pm 0.2 ^b	635 \pm 17 ^a	584 \pm 23 ^a
Groundnut haulm	88 \pm 4 ^a	139 \pm 7 ^b	436 \pm 17 ^c	315 \pm 15 ^b	9.1 \pm 0.1 ^b	633 \pm 9 ^a	522 \pm 11 ^a
Cottonseed cake	55 \pm 1 ^b	301 \pm 6 ^a	477 \pm 12 ^c	318 \pm 12 ^b	7.9 \pm 0.2 ^c	593 \pm 11 ^b	167 \pm 5 ^c
Bush hay	46 \pm 7 ^c	20 \pm 3 ^d	832 \pm 11 ^a	536 \pm 9 ^a	6.1 \pm 0.1 ^d	408 \pm 8 ^c	171 \pm 7 ^c
Concentrate	87 \pm 2 ^a	177 \pm 8 ^b	408 \pm 12 ^c	130 \pm 22 ^c	9.2 \pm 0.1 ^b	648 \pm 9 ^a	158 \pm 3 ^c
Cereal bran	98 \pm 8 ^a	128 \pm 10 ^c	443 \pm 16 ^c	187 \pm 21 ^c	8.4 \pm 0.3 ^c	592 \pm 19 ^b	145 \pm 4 ^c
Browse	44 \pm 1 ^c	128 \pm 4 ^c	553 \pm 10 ^b	306 \pm 16 ^b	10.2 \pm 0.1 ^a	680 \pm 5 ^a	237 \pm 18 ^b

DM: dry matter; NDF and ADF: fiber components; ME: metabolizable energy; OMD: organic matter digestibility

¹ 1 USD \approx 500 FCFA

² Comparison of each feed type across seasons showed significant differences ($p < 0.05$) for the nutritional quality of the following feeds: browse (crude protein and ME were higher in wet season than in late dry season); cereal bran (ash content was higher in late dry season than in wet season); cowpea hay (crude protein and *in vitro* OMD were higher in wet season than in early and late dry seasons); bush hay (crude protein was higher in wet season than in early and late dry seasons).

Values with different superscript letters within the same column denote significant differences ($p < 0.05$) between means for each season.

Table III

Validation of NIRS equations for the prediction of quality of feed resources

Variable	Num. samples	Prediction error	R ²	GH
DM	147	0.358	0.814	1.120
Ash	147	1.842	0.726	1.120
Nitrogen	147	0.244	0.966	1.120
ME	147	0.242	0.952	1.120
IVOMD	147	2.239	0.923	1.120
NDF	804	2.721	0.965	0.973
ADF	804	1.959	0.947	0.973

NIRS: near infrared reflectance spectroscopy

GH: distance between the sample and the calibration database. Distances > 3 are considered as outliers.

DM: dry matter, ME: Metabolizable energy, IVOMD: *in vitro* organic matter digestibility; NDF and ADF: fiber components

Mali's specific database was used for sample analysis for DM, ash, nitrogen, ME and IVOMD, whereas the global database was used for analysis of NDF and ADF.

of the former. Comparison of the nutritional quality of each feed type across the three seasons showed that the quality (ash, crude protein, NDF, ADF, ME and IVOMD) of concentrates, cottonseed cake and cereal bran did not vary significantly. The crude protein contents of cowpea hay and of bush hay were significantly higher in the wet season than in the early and late dry season. The crude protein content and ME of browse species were significantly higher in the wet season than in the late dry season.

Relationship between price and feed quality

The analysis of variance did not show a relationship between price and feed quality, in other words the quality of feed did not influence the price at the market for all feed types. This implies that feeds of the same quality were sold at different prices depending on the season and market. Results further showed that the price and nutritional quality of most of the feeds varied across seasons (Table V). The prices of cowpea hay, groundnut haulm, bush hay and browse were significantly affected by the season (Table V). Prices of these feeds declined as the season progressed from wet to dry except for browse species in which case the price increased significantly in the late dry season compared to the wet season.

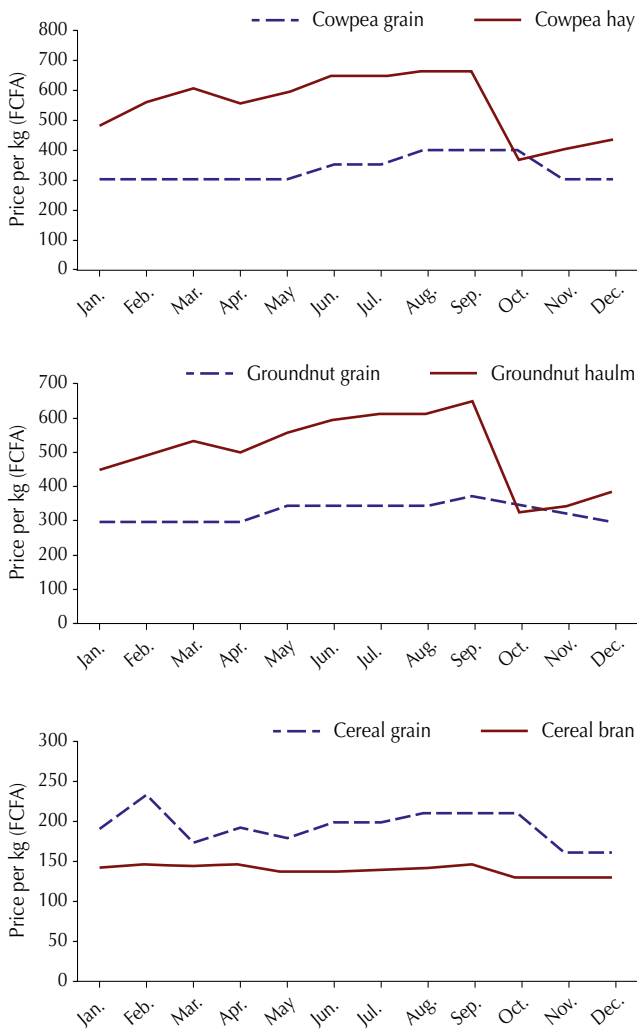


Figure 1: Comparison between grain prices and by-products or residues; 1 USD ≈ 500 FCFA.

The season also had a significant effect on the crude protein content of browse species, cowpea hay and bush hay.

Cost implications of livestock feed prices for sheep fattening in suburban areas

The analysis of cost and benefit of sheep fattening showed that concentrates for ruminants can be used as substitutes for cowpea hay or groundnut haulm for sheep fattening in suburban areas in the region (Table I). The results also suggested that it was not economically profitable to fatten sheep with cowpea-hay-based diet in both the early and late dry seasons if the animals were destined to be sold during the ordinary period (Table VI). If the animals were sold during the Tabaski when the sales price was high, there could be positive net returns from fattening with a cowpea-hay-based diet in the early dry season. The cost-benefit analysis also suggested that it was more profitable to fatten sheep with a concentrate-based diet than with a cowpea-hay based diet in both the early dry and late dry seasons (Table VI).

DISCUSSION

The results obtained from the five monitored markets confirmed the common observation that livestock feeds are expensive in urban and suburban areas of West Africa's Sahel (5, 10, 11, 15, 19, 22). The prices of bush hay and cowpea hay in our study agreed with the ranges between 65 and 300 FCFA/kg DM, and between 330 and 800 FCFA/kg DM, respectively, reported for livestock productions in suburban Niamey in Niger by Bayala et al. (5) and Diogo et al. (11). In suburban areas of Niger, Bayala et al. (5) reported high prices between 125 and 351 FCFA/kg DM for hay of *Zornia glochidiata*. The feed prices observed in our study were much higher than 25 FCFA/kg DM for bush hay and 75 FCFA/kg DM for groundnut haulm reported by Ayantunde et al. (3) in feed markets in rural areas in Southwestern Niger, and 148 FCFA/kg DM for groundnut haulm reported by Bayala et al. (5) in rural

Table IV

Monthly price variations for different feed types (FCFA¹/kg DM, mean ± standard error) in five markets monitored in 2010 in Bamako, Mali

Month	Cowpea hay	Groundnut haulm	Cottonseed cake	Bush hay	Concentrates for ruminant	Cereal bran	Browse ²
January	493 ± 49 ^{bc}	454 ± 9 ^{ef}	159 ± 5 ^a	139 ± 4 ^b	152 ± 3 ^a	144 ± 3 ^a	-
February	568 ± 34 ^{ab}	494 ± 17 ^{de}	174 ± 7 ^a	164 ± 6 ^{ab}	144 ± 3 ^a	148 ± 4 ^a	298 ± 12 ^a
March	610 ± 20 ^a	533 ± 9 ^{cd}	162 ± 2 ^a	160 ± 28 ^{ab}	163 ± 3 ^a	145 ± 5 ^a	233 ± 36 ^a
April	561 ± 15 ^{ab}	503 ± 8 ^{de}	167 ± 3 ^a	171 ± 7 ^{ab}	152 ± 4 ^a	146 ± 4 ^a	270 ± 20 ^a
May	598 ± 10 ^a	558 ± 8 ^{bcd}	165 ± 2 ^a	187 ± 7 ^{ab}	164 ± 3 ^a	139 ± 2 ^a	146 ± 8 ^b
June	651 ± 8 ^a	597 ± 4 ^{ab}	164 ± 2 ^a	186 ± 7 ^{ab}	160 ± 4 ^a	138 ± 8 ^a	132 ± 3 ^b
July	650 ± 12 ^a	612 ± 6 ^{ab}	180 ± 12 ^a	206 ± 10 ^a	157 ± 2 ^a	141 ± 2 ^a	164 ± 26 ^{ab}
August	667 ± 9 ^a	611 ± 6 ^{ab}	165 ± 3 ^a	-	162 ± 5 ^a	142 ± 4 ^a	189 ± 27 ^{ab}
September	665 ± 6 ^a	649 ± 9 ^a	166 ± 3 ^a	-	164 ± 5 ^a	146 ± 3 ^a	111 ± 3 ^b
October	367 ± 11 ^d	326 ± 10 ^g	163 ± 2 ^a	-	172 ± 6 ^a	131 ± 3 ^a	100 ± 11 ^b
November	411 ± 8 ^{cd}	345 ± 8 ^g	163 ± 3 ^a	106 ± 5 ^b	161 ± 4 ^a	132 ± 3 ^a	95 ± 9 ^b
December	438 ± 4 ^{cd}	387 ± 5 ^{fg}	164 ± 5 ^a	132 ± 8 ^b	173 ± 6 ^a	131 ± 3 ^a	108 ± 2 ^b

¹ 1 USD ≈ 500 FCFA

² Browse found in the markets were leaves of *Combretum micranthum*, *Piliostigma reticulatum*, *Pterocarpus erinaceous*, and fruit of *Acacia albida*. Values with different superscript letters within the same column denote significant differences (p < 0.05) between means for each feed type.

Table V

Analysis of variance of the effect of season on the response variables (nutritional quality and price) of different feed types¹

Feed	Response variable	Explanatory variable	Parameter estimate	Standard error	F-value	P > F
Browse	Crude protein	Constant	189	19	94	0.0006
		Late dry	-61	24	6	0.0435
	ME	Constant	9.5	0.2	2,683	< 0.0001
		Early dry	-0.9	0.2	20	0.0114
	IVOMD	Late dry	0.7	0.2	10	0.0353
		Constant	668	11	3,754	< 0.0001
	Price	Early dry	-83	14	33	0.0353
		Constant	91	18	25	0.0039
	Late dry	166	34	24	0.0045	
Cereal bran	IVOMD	Constant	647	24	717	< 0.0001
		Early dry	-61	31	4	0.0436
	ME	Constant	9.3	0.3	745	< 0.0001
		Early dry	-0.9	0.4	4	0.0425
	Late dry	-0.8	0.4	4	0.050	
Cottonseed cake	Price	Constant	165	5	1,119	< 0.0001
		Late dry	23	8	7	0.0098
Groundnut haulm	Price	Constant	613	15	1,609	< 0.0001
		Early dry	-215	20	120	< 0.0001
		Late dry	-87	20	20	< 0.0001
Cowpea hay	Crude protein	Constant	217	16	188	< 0.0001
		Early dry	-59	19	10	0.0032
		Late dry	-55	20	8	0.0080
	Price	Constant	659	22	865	< 0.0001
		Early dry	-228	27	73	< 0.0001
		Late dry	-72	28	7	0.0142
Bush hay	Crude protein	Constant	36	5	52	< 0.0001
		Early dry	-23	7	9	0.0081
		Late dry	-16	6	7	0.0157
	Price	Constant	175	8	474	< 0.0001
		Early dry	-59	19	9	0.008

¹ Only variables that were significant at $p < 0.05$ were included.

ME: metabolizable energy; IVOMD: *in vitro* organic matter digestibility

areas in Burkina Faso. Because of the low prices of livestock feeds in rural areas, feed sellers in urban and suburban areas tend to buy their products from these markets. In addition, in rural areas there are local buyers or collectors of crop residues, particularly cowpea hay, groundnut haulm and bush hay, who often transport these feeds with donkeys and camels to urban and suburban areas for sale mainly to feed sellers. The System-Wide Livestock Program reports negative environmental impacts of total removal of crop residues from soil, driven partly by market opportunities in urban and suburban areas in a study based on trade-offs between stover and haulm in the dry savannah of Ghana, Nigeria and Niger (25). But this trend of total removal of crop residues from soil will probably continue in the region (14).

These results reaffirm that the major production cost in urban and suburban livestock husbandry in the Sahel is feed cost which often accounts for at least 60% of total costs (10). The high cost

of feeds in suburban areas raises the question of profitability of livestock husbandry in this zone. In a study on suburban smallholder dairy production by Debrah et al. (10) in Bamako in 1990, the authors reported that the production cost ranged from 110 to 195 FCFA per liter of milk, whereas a liter of milk was sold between 100 and 250 FCFA, which showed that the profit was minimal if any at all, if milk alone was considered as the farm product. Although this study is old, the trend concerning the profitability of smallholder dairy in a suburban zone is not likely to be different today, even if the milk price has increased in Bamako compared to that of the 1990s. Optimization of livestock feeding strategies in terms of what and how much is offered is therefore critical to reduce waste, enhance resource use efficiency and thus generate profit in these urban and suburban areas (18, 22). It will be necessary to provide information or practical guidelines on what to feed the animals, what quantities, and in what

Table VI
Four scenarios¹ for the feed costs of sheep fattening in the West African Sahel based on diets formulated in Table I

	Scenario			
	Early dry season sale - Tabaski	Early dry season sale - Normal	Late dry season sale - Tabaski	Late dry season sale - Normal
a. Total feed required for 90 days' fattening (kg DM)	135	135	135	135
b. Total feed cost for cowpea-based diet if 100 kg = 29,008 FCFA ² in early dry season and 39,480 in late dry season	39,160	39,160	53,298	53,298
c. Total feed cost for concentrate-based diet if 100 kg = 15,406 FCFA in early dry season and 15,870 in late dry season	20,798	20,798	21,425	21,425
d. Buying price of 25 kg ram at 400 FCFA/kg in early dry season and 300 in late dry season	10,000	10,000	7,500	7,500
e. Sales price at 34 kg (FCFA)	57,800	28,900	51,000	25,500
f. Net return for cowpea-based diet (e, b, d) (FCFA)	8,640	-20,260	-9,798	-35,298
g. Net return for concentrate-based diet (e, c, d) (FCFA)	27,002	-1,898	22,075	-3,425

¹ Duration of fattening was 90 days; daily diet offered (on dry matter basis) was 1.5 kg. In the early dry season the price of ram during an ordinary period was assumed to be 850 FCFA/kg live weight (LW), whereas it was twice that during the Tabaski (1,700 FCFA/kg LW). If the initial weight was 25 kg and average daily gain was 100 g/day (Ayantunde et al., 2008), the selling weight was 34 kg. For the late dry season the price of ram during an ordinary period was assumed to be 750 FCFA/kg LW, whereas it was twice that during the Tabaski (1,500 FCFA/kg LW). The sales price of animals was generally cheaper in the late dry season because many animals were for sale in the markets due to feed scarcity.

² 1 USD ≈ 500 FCFA

combinations with other feeds to meet different production objectives. However, it has to be emphasized that there are livestock keepers in urban and suburban areas of West Africa's Sahel whose objective is not strictly to make profit, particularly those who are relatively wealthy. These livestock keepers establish livestock enterprises, often smallholder dairy with crossbred cows (local breeds crossed with European breeds) as an expression of their wealth and sometimes of their culture, especially those who are from pastoral ethnic groups. For poor livestock keepers in urban and suburban areas, the challenge of making profit through their livestock enterprise is always present and they address this by taking their animals to graze on the outskirts of towns thereby reducing feed cost.

The high prices of feed types such as cowpea hay and groundnut haulm in the markets we monitored were a reflection of the high demand for these feeds and not of their quality as shown by the results of the relationship between price and quality. For example, the prices of cowpea hay and groundnut haulm were at least twice that of concentrate feeds for most of the year despite the fact that their nutritional quality in terms of crude protein, ME and IVOMD was comparable all year round. Livestock keepers could easily reduce their feed cost by feeding concentrates instead of cowpea hay and groundnut haulm but this did not happen for two reasons. Firstly, there is a general perception among livestock keepers in suburban areas of West Africa's Sahel that cowpea hay and groundnut haulm are the best feeds particularly for animal fattening and for dairy cows (5). Its origin might be found in the long tradition of feeding animals with cowpea hay and groundnut haulm (3). Secondly, concentrates for ruminants are relatively new in the markets in Bamako and livestock keepers are not yet well informed on the nutritional quality of these feeds, which might have accounted for their low demand and low price despite their

good nutritional quality. However, it has to be noted that concentrates cannot completely replace cowpea hay and groundnut haulm because ruminants need fiber in their diet.

Given the growing livestock population in urban and suburban areas of West Africa's Sahel and the associated rise in the demand for livestock feeds (5, 11, 15), there are market opportunities for fodder production in the region. Fodders can be grown along the banks of Niger River in Bamako, Mali, and Niamey, Niger, but they will have to face stiff competition for land from vegetable and crop production which is widespread along the river banks (15) in both cities. In addition, available land is decreasing in most suburban areas of West Africa as a result of increased urbanization (1). Another challenge to fodder production is availability of seed because most of the varieties of cowpea and groundnut in the region are mainly for grain production and they are unsuitable for fodder production (18). According to these authors forage yield and quality are not often part of selection criteria in groundnut improvement programs in West Africa. In the case of cowpea, dual-purpose varieties have been developed in the region but the adoption has been local and low (24).

The results of the nutritional quality of different feed types sold at the five feed markets in Bamako generally agree with results in the West African Sahel reported by other authors (3, 5, 17, 20, 23). For example, the values in our study of 284 to 390 g/kg DM for crude protein content for cottonseed cake were similar to those reported by Kiema et al. (17), and Sanon et al. (23). The values in our study for crude protein content of groundnut haulm were slightly higher than those of 82 to 126 g/kg DM reported by Nantoumé et al. (20). This could be attributed to a higher leaf to stem ratio of groundnut haulm sold in the markets compared to those used in the feeding trials by the above-mentioned authors as reflected by lower NDF

and ADF values in our study than those reported by these authors (20). The nutritional quality of the browse species (*Combretum micranthum*, *Piliostigma reticulatum*, *Pterocarpus erinaceus*) sold at the surveyed markets was generally good in terms of crude protein, digestibility and ME. However, their tannin content is a major limiting factor to their nutritional value in the diet of ruminants (5).

The analysis of variance revealed that the quality of feed did not influence the price but that the season did. Moreover, the results confirmed that the interplay between demand and supply, which is largely influenced by the season with respect to crop residues, determines the prices in suburban markets (14). The high cost of crop residues (cowpea hay, groundnut haulm and bush hay) in the wet season could be attributed to the acute scarcity of these feeds during this period as markets still depended on crop residues from the previous cropping season and, by then, the stocks were usually very low. In addition, the high costs of cowpea hay and groundnut haulm observed in this study could also be attributed to the high demand in the wet season because of the Tabaski. In view of the availability of pastures in the wet season on the outskirts of many towns in the West African Sahel, Graef et al. report that many livestock keepers usually take out their animals for grazing during the day and give them supplements such as cottonseed cake, cereal bran, cowpea hay and groundnut haulm upon return (15). According to these authors, livestock keepers in urban and suburban areas that cannot take out their animals for grazing because of the nature of their work usually hire herders often paid in cash to do it. From the perspective of price, livestock feeds (crop residues) prices are lowest in the early dry season, particularly after the grain harvest. Livestock keepers could take advantage of this situation by buying crop residues at that time although their bulkiness poses the problem of storage.

The cost-benefit analysis of using cowpea hay and concentrate feed for sheep fattening showed that it was not profitable in suburban areas during an ordinary period. However, it was profitable during the Tabaski when the sales price of sheep was generally high. Sheep fattening in the West African Sahel is mainly driven by the Tabaski because of the large Muslim population in the region (4). Despite the high price of cowpea hay and groundnut haulm, many people in suburban areas still used them for sheep fattening but often offered these feeds in much lower quantities than we assumed in our analysis to minimize costs. Besides, many people did not usually offer a balanced diet to their animals at the quantity assumed in our calculations and for the whole duration of fattening.

■ CONCLUSION

As a result of the increase in livestock population and the associated growth in the demand for feeds, feed markets have sprung up in many cities and towns of West Africa's Sahel. Results from the survey of five livestock feed markets in Bamako showed that there was no relationship between feed price and quality but that the main determinant was the season. In view of the high price of crop residues, particularly cowpea hay and groundnut haulm, there are market opportunities for fodder production in suburban areas of West Africa's Sahel. More studies are needed to understand further the reasons for the high prices of some feeds such as cowpea hay and groundnut haulm over most of the year, and to investigate the social economic profiles of feed buyers, their reasons for buying different feed types, and their perception of feed quality. Future studies should also assess the cost and benefit of selling feeds, seasonal variations in volumes of different feeds, provenance of feeds, and sellers' perception of quality.

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Résumé

Ayantunde A.A., Blummel M., Grings E., Duncan A.J. Prix et qualité des aliments du bétail dans les marchés périurbains du Sahel Ouest africain : étude de cas à Bamako, Mali

Dans les villes du Sahel Ouest africain, les activités liées à l'élevage, comme la production laitière des petits exploitants et l'engraissement du bétail (bovins, ovins et caprins), sont devenues très répandues pour satisfaire aux besoins en alimentation du ménage et pour générer des revenus. L'importance accrue de l'agriculture urbaine et périurbaine, en particulier des activités d'élevage dans la région, a contribué à une croissance rapide du cheptel dans la plupart des grandes villes. En réponse à cette croissance et, ainsi, à la demande accrue en aliments, des marchés des aliments du bétail se sont développés dans plusieurs grandes villes du Sahel Ouest africain. Une enquête sur les marchés des aliments du bétail a été conduite au Mali dans cinq marchés de Bamako. Le prix des aliments a été suivi mensuellement de janvier à décembre 2010. En outre, des échantillons d'aliments ont été collectés pour analyser leur qualité nutritionnelle. Les résultats ont montré que les prix de la fane de niébé et de la fane d'arachide étaient plus élevés que ceux des autres aliments tout au long de l'année. Le prix de la fane de niébé a varié entre 367 FCFA/kg de matière sèche (1 USD ≈ 500 FCFA) en octobre, soit juste après la récolte, et 667 FCFA/kg en août, pendant la saison humide. Les résultats ont également montré qu'il n'y avait pas de relation entre le prix et la qualité pour tous les types d'aliments. Cependant, leur prix et leur qualité ont considérablement varié en fonction des saisons, indiquant que la saison était un déterminant majeur du prix des aliments de bétail dans les zones périurbaines du Sahel Ouest africain.

Mots-clés: Bétail – Agriculture périurbaine – alimentation pour animaux – Prix – Qualité – Valeur nutritive – Marché des produits agricoles – Sahel.

Resumen

Ayantunde A.A., Blummel M., Grings E., Duncan A.J. Precio y calidad de alimento para ganado en mercados suburbanos en el Sahel de África del Oeste: Análisis de un caso en Bamako, Malí

En las ciudades del Sahel de África del Oeste, la cría de ganado, en forma de pequeños productores lecheros y de engorde de carne (bovino, ovino y caprino), se está tornando popular entre los propietarios de ganado, con el fin de satisfacer las necesidades en alimento para los hogares y para generación de ingresos. La creciente importancia de agricultura urbana y suburbana en la región, particularmente cría de ganado, ha llevado a un aumento rápido de la población de ganado en la mayoría de las ciudades y pueblos grandes. Como resultado de este aumento en la población de ganado y el crecimiento asociado con la demanda de alimentos, han surgido mercados alimenticios en varias ciudades y pueblos del Sahel de África del Oeste. Una encuesta sobre los mercados de alimentación de ganado fue llevada a cabo en cinco mercados de Bamako, Malí. Los precios de los alimentos de ganado fueron monitorizados mensualmente de enero a diciembre 2010. Además, se colectaron muestras de alimentos de los mercados para análisis de laboratorio, con el fin de determinar la calidad nutricional. Los resultados muestran que los precios de heno de caupí y tallo de maní fueron consistentemente más elevados que los de otros alimentos a lo largo del año. El precio del heno de caupí varió alrededor de 367 FCFA/kg de materia seca (MS) (1 USD ≈ 500 FCFA) en octubre, por ejemplo inmediatamente después de la cosecha, hasta 667 FCFA/kg MS en agosto, por ejemplo durante la estación seca. Los resultados también muestran que no hubo relación entre precio y calidad para todos los alimentos. Sin embargo, los precios y la calidad de los alimentos difirieron significativamente a través de las estaciones, sugiriendo que la estación fue un mayor determinante para el precio de los alimentos de ganado en las zonas suburbanas del Sahel del Oeste de África.

Palabras clave: Ganado – Agricultura peri urbana – Pienso – Precio – Calidad – Valor nutritivo – Mercado de productos básicos – Sahel.

