Farmers' storage practices and nutritional quality of fodder from dual-purpose cowpea and sorghum crops

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Abstract

The study aim was to analyze the effect of storage practices for cultivated forages on their nutritional qualities. Post-harvest fodder storage practices for cowpea var. KVX 745-11p and sorghum var. Grinkan were observed at 44 farms. Samples of green fodder and fodder stored under different conditions after drying were analyzed in laboratory to determine chemical composition parameters using near infrared spectrometry. The results showed that the most common storage is exposure in sheds (34% of farmers). The sensory assessment of the forage showed that sheltered premises help to maintain a relatively very good (52%) to good (40%) quality of stored forage. In unsheltered premises, stored fodder is essentially of good (68%) to fair (26%) quality. The quality of fodder stored in unsheltered premises deteriorates with a significant reduction in crude protein content. This content varies significantly from 20% for green fodder to 16% in sheltered premises, then to 15% in unsheltered premises for cowpea, and for sorghum from 7.9% to 6.6% and then to 4.5%. West African livestock farmers need to adopt better storage practices for cultivated fodder and crop residues to preserve their nutritional value.

Keywords: Fodder, Dual-purpose crop, Storage practices, Nutritional value, Sub-Saharan Africa

INTRODUCTION

Livestock systems in West Africa are traditionally predominantly pastoral, agropastoral, or increasingly specialized for commercial purposes (Diop, 2015; Hamadou *et al.*, 2003). In agropastoral systems, livestock plays an important role in food security by providing sources of protein (meat, milk), agricultural energy (traction force) and manure for fertilizing fields (Blanchard *et al.*, 2013). In addition, it constitutes the main form of savings for rural households who have little access to the banking system (Alary *et al.*, 2011).

In Burkina Faso, the local milk sector, currently supported by dairy cattle farming, has experienced strong momentum in recent years, due in particular to the commitment of stakeholders to respond to the rapid growth in consumer demand for this product. The milk producing farmers who supply the largest quantities of milk to the local sector are the traditional family dairy farms whose milk production falls in the dry season mainly due to poor feeding and water drinking conditions for the producing females (MRA, 2010; Sib *et al.*, 2017). Indeed, the animal feeding system practiced by these farms is based on the almost exclusive exploitation of natural pastures to which access, quality and quantity are increasingly limited. In this context, milk-producing farmers have an increasing tendency to use crop residues, particularly cereals, and they are expressing interest in fodder crops (Sodré *et al.*, 2022). However, it is well known that crop residues have a low food value and that off-farm food concentrates experience a surge in their prices during the dry period of the year, all of which leads to an increase in milk production costs (IUCN, 2015).

To overcome the constraints of cow feeding and with the objective of improving technical and economic performance of traditional Burkinabè dairy systems, research has been increasingly oriented towards the cultivation of good quality fodder (Sikora *et al.*, 1982; Obulbiga *et al.*, 2015; Sib *et al.*, 2020; Sodré, 2022). If the agronomic performances of these crops are well highlighted and documented, there is little information on the quality of the preserved fodder from these crops.

In the usual practices of farmers, the collection of legume tops and cereal stalks is done late and their storage most often on sheds, trees and on the ground (Savadogo *et al.*, 1999). Although it is admitted that poor practices in harvesting, tedding, transport and storage cause enormous losses in nutrients from harvested fodder (Savadogo *et al.*, 1999; Lawal *et al.*, 2017), there is however no recent figures to support these assertions.

The present study has the objective of identifying the different storage practices for cowpea tops and dual-use sorghum stalks grown in western Burkina Faso by traditional family dairy farms and to assess the effect of these storage practices on fodder nutritional value. The expected results would serve to inform and raise awareness among stakeholders on good practices for harvest, conservation and storage of cultivated fodder and harvest residues, so as to contribute to increasing the availability of quality fodder and optimizing its use in improving local dairy production.

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MATERIAL AND METHOD

Study zone

The study took place in the west of Burkina Faso, in the dairy basins of Bobo-Dioulasso (Houet Province) and Banfora (Comoé Province) precisely in the communes of Bama, Bobo-Dioulasso and Satiri belonging to the province of Houet on the one hand and on the other hand in the communes of Banfora, Mangodara and Tiéfora in the province of Comoé.

The area formed by the two provinces is almost entirely included in the South Sudanian climatic zone (Figure 1). In this region, two very distinct seasons alternate: a long dry season which lasts from November to May and a relatively short rainy season from June to October with average rainfall fluctuating between 800 and 1200 mm per year (Zida/Bangre, 2009). During the 2020 agricultural campaign (year in which the experiments were conducted), the average precipitation recorded in Houet and Comoé was respectively 1100 and 1189 mm.

The soils we encounter in the study area are of several types, but those of great agronomic interest are brown soils and hydromorphic soils. Areas unsuitable for agriculture cover areas of ferruginous crusts and rock outcrops. These bare soils are very present in the northern part of the area (Figure 1).

Economically, the main production activities of rural populations in the study area are represented by agriculture and livestock breeding. Agriculture is strongly dominated by the cultivation of cotton, followed by that of traditional cereals and lowland rice. Furthermore, fruit trees (bananas, mangoes, citrus, cashew nuts) are rapidly developing, stimulated by the international market for fruit products (MAAH, 2010). In general, the production and marketing of products is organized within agricultural cooperatives which therefore benefit from support from State services and certain non-governmental organizations (NGOs).

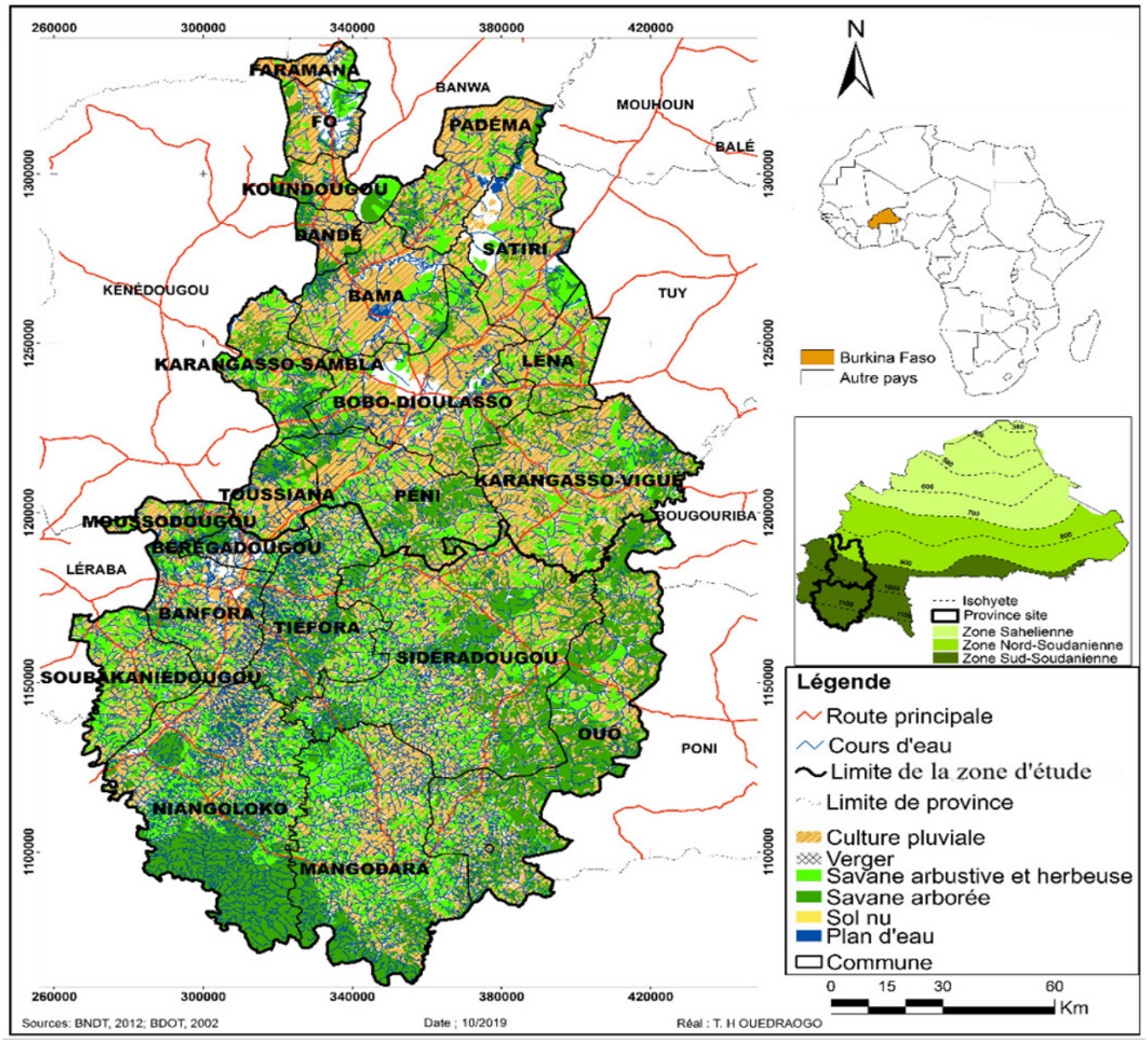

Figure 1: Map presentation of the study area

Livestock farming, which is most often practiced in integration with agriculture, constitutes the economic activity of the vast majority of the rural population in the study area. The most exploited animal species are cattle, sheep, goats, pigs and poultry. The number of cattle in the study area was estimated at 901,000 heads, or 12% of the country's total cattle population (MAAHM, 2020).

Analysis of the local dairy sector shows that the production aspect is strongly dominated by traditional pastoral and agro-pastoral dairy farmers (MRA, 2010). Several breeds of cattle are maintained but the most represented are the local zebu and their crossbreeds with bullocks. There are also some Goudali, Gir, M'Bororo and Azawak zebus and their mixed breeds (Zampaligré, 2019). Pasture constitutes the main resource exploited by the entire herd, but during the lean period, lactating cows benefit from food supplements that are relatively low in quality and quantity. In these precarious conditions, cow productivity is generally low, from 1.4 to 3.1 l/day (Sib *et al*., 2017; Vall *et al*., 2021).

In a context of low availability of fodder resources linked to the deterioration of pedo-climatic conditions, fodder crops are one of the options for developing livestock farming, particularly dairy farming. However, we observe that the level of use of fodder crops can be improved in cattle farms in western Burkina Faso, despite the efforts made by stakeholders such as making fodder seeds available to farmers with high forage production potential (Hamadou *et al*., 2005; Coulibaly *et al*., 2012, Sodré *et al*., 2022). The reasons which explains this situation are to the lack of mastery of good farming techniques, the unsuitable socio-economic situation of the farmers, and poor environmental and climatic conditions, etc. (Hamadou *et al*., 2005; IUCN, 2015). Added to this are more particularly the practices of harvesting and storing fodder, using old habits of the farmer and which strongly contribute to deteriorating the quality of the fodder preserved in the dry season by making it less valuable to the cows. Raising awareness among farmers on good practices for harvesting and storing fodder is therefore necessary to contribute to the proper integration of fodder cultivation into dairy farms in order to improve the availability of fodder on these farms and increase their production.

Plant material

The plant material was composed of fodder from Cowpea KVX 745-11p and Sorghum Grinkan, two varieties of dual-use crops whose grains can be used in human food while the tops (stems and leaves after grain harvest) and the stems are used as animal feed. These varieties of cowpea and sorghum were grown by volunteer test farmers (ETV) as part of the Africa Milk project during the 2020 agricultural campaign for fodder production with the aim of supplementing milking cows in the 2021 dry season.

Each farmer received a seed kit of one of the two varieties as well as brief training on the technical process of producing, harvesting, preserving and storing fodder. The different means and equipment used from production to storage of fodder were the responsibility of the farmers.

Methodological approach and experimental setup

The activities of this study were carried out according to the on farm experimentation methodological approach based on the "Experimentation Chez et Par le Paysan" (ECPP) by Chia (2004), adapted by Coulibaly *et al*. (2012). This involved monitoring and evaluating storage/conservation practices for cowpea tops var. KVX 745-11p and Grinkan sorghum stalks produced with the support of the project. The experimental system is made up of blocks of 44 traditional dairy farms that are members of the multi-actor milk innovation platforms (PIL) of Bobo Dioulasso and Banfora, 36 of which have opted for KVX 745-11p cowpea and 8 for Grinkan sorghum and where each farmer represents a repetition.

Data Collection

Analysis of storage practices and sensory assessment of fodder quality

During a monitoring mission to ETVs, direct observation and semi-structured interviews were used to collect information on equipment and practices for storing fodder for dual-use crop varieties.

A sensory assessment of the quality of the fodder (visual color, odor, friction to the touch, etc.) in the storage conditions was made. Four (4) levels were used to qualify the quality of the different fodders observed: very good quality fodders, good quality fodders, average quality fodders and poor-quality fodders**.**

Samples of 1000 g of fodder were taken under the storage conditions observed at each ETV for laboratory analyses.

It should be noted that for the purposes of comparison, samples of green fodder were previously taken for laboratory analyzes as well**.**

Determination of the chemical composition and nutritional value of fodders

The fodder samples from the two dual-use crop varieties were the subject of bromatological analyzes at the Animal Production and Health Research Laboratory (LAREPSA) in Kamboinsé using the near-infra-red spectrometry (SPIR) method. For the analysis of green fodder, homogeneous samples of fodder from all the cultivation plots were constituted. As for the stored fodder, homogeneous samples were made from fodder from the same type of storage equipment. The analysis focused on the determination of the content of dry matter (DM), mineral matter (MM), crude proteins (CP), fibers (NDF, ADF, ADL), digestibility of organic matter (dMO) and metabolizable energy (ME) content.

Data analysis

All the data collected in the field and those resulting from laboratory analysis were recorded, then processed using the Excel 2019 spreadsheet. Descriptive statistics and comparisons of means using Anova and non-parametric tests (Kruskal-Wallis' test) were carried out. Tukey's tests (pairwise t-test) were used to separate the groups at the 5% threshold in the event of significant differences. All statistical analyzes and tests were performed using R software version 4.3.1 (R Core Team, 2021).

RESULTS

Storage practices for cowpea haulms and sorghum stalks by breeders

The dairy farms under investigation use various equipment according to their storage procedures for sorghum fodder and cowpea tops. The study's farmers can be divided into two groups based on whether or not they employ equipment that can provide ideal storage conditions for fodder (Table 1):

- Farmers storing their fodder in "sheltered premises" (55% of breeders) including haylofts, huts, stores, the underside of the sheds the fodder being stored on racks, the top of the sheds with a covering of the fodder by tarpaulins, other fodder or other materials;
- Farmers using "unsheltered premises" (45% of breeders) consisting of storing them in sheds (without covering the fodder) or on trees, thus exposing them to weather (sun, rain, winds, etc.).

It appears that even if overall the use of "sheltered premises" outweighs that of "unsheltered premises" in terms of frequency, the most common practice is the storage of fodder (both cowpea tops and stems of sorghum) on sheds without covering them. This is practiced by 34% of breeders.

Sensory assessment of forage quality according to storage practices

Field observations and elements of the literature on the characteristics of good hay (Le Manse *et al.*, 2018; Sollio Agriculture, 2023) made it possible to propose a scale for assessing the quality of forage at four levels ranging from better to poor quality forage (Table 2).

The results of the sensorial assessment of the quality of the fodder in the storage conditions at the farms are given in Table 3. Overall, the storage conditions in sheltered premises made it possible to maintain a relatively very good quality of the fodder (52%).

In unsheltered premises, the fodder stored is essentially of good quality (68%), to fair (26%). We also encounter poor quality fodder (5%) with these storage methods. For sorghum, fodder stored in unsheltered premises is even of fair (50%) and poor (50%) quality. For cowpea, the tops kept in sheltered premises are of very good (58%) to good (37%) quality with a low proportion of fodder of average quality (5%). The tops kept in unsheltered premises are mainly of good quality (76%) with a significant proportion of fodder of average quality (24%).

Table 1: Proportions of dairy farmers in western Burkina Faso according to storage practices for cowpea tops and dual-use sorghum stalks

Practices/ Storage equipment		Grinkan sorghum		Cowpea KVX745-11p		Total Sorghum and Cowpea (%)
		Proportion	Number	Proportion	Number	
Sheltered premises	Fennel	2	25%	6	17%	18%
	Store	2	25%	6	17%	18%
	Hut	0	0%	0	0%	0%
	Under shed	0	0%	4	11%	9%
	On shed with cover	1	13%	3	8%	9%
Unsheltered premises	On shed without cover	3	38%	12	33%	34%
	On tree	0	0%	5	14%	11%
Total		**8**	**100%**	**36**	**100%**	**100%**

Table 2: Sensorial assessment grid for the quality of hay and harvest residues in a tropical environment

Appreciation		Very good quality	Good quality	Average quality	Poor quality
Forage characteristics	**Color**	Green	Greenish (Yellow green)	Yellow, Gray	Yellow, Yellow spotted with white areas, Brown, Black gray
	Proportion leaves and stems	Great proportion of leaves	Good proportion of leaves	Weak proportion of leaves	Almost total absence of leaves
	Rigidity to the touch	Flexible	Flexible enough	Rigid, Breaks easily while handling	Very rigid, Breaks easily while handling
	Smell	Pleasant (no must or caramel)	Pleasant	Burned	From rot, mold, must or caramel

Table 3: Sensory assessment of the quality of harvested dual-use sorghum and cowpea fodder in the storage conditions of dairy farmers in western Burkina Faso

Sensorial assessment of fodder quality		Very Good	Good	Average	Bad	Total
Sorghum *Grinkan*	Sheltered premises	33%	50%	17%	0%	100%
	Unsheltered premises	0%	0%	50%	50%	100%
Cowpea *KVX745-11p*	Sheltered premises	58%	37%	5%	0%	100%
	Unsheltered premises	0%	76%	24%	0%	100%
Fodder (sorghum and cowpea)	Sheltered premises	52%	40%	8%	0%	100%
	Unsheltered premises	0%	68%	26%	5%	100%

Legend: Sheltered premises: Hut, Fennel, Store, under shed, on covered shed; Unsheltered premises: On tree, On shed without covering

Chemical composition and nutritional values of KVX 745-11p cowpea haulms according to storage practices

Table 4 presents the comparative nutritional values of cowpea var. KVX 745-11p from different storage methods with green fodder of the same variety. The results show that before tedding and storage, the crude protein (CP) contents of green forage are significantly higher than those of stored hay. On the other hand, the dry matter and fiber contents of KVX 745-11p cowpea green fodder are significantly lower than those of hay in these elements. No significant differentiation was observed between the green fodder of Cowpea KVX 745-11p and its preserved tops, in terms of metabolizable energy content and in terms of digestibility of organic matter (Table 4).

Under storage conditions, the BP content of cowpea hay stored in sheltered premises (16% DM) is significantly higher than that of hay stored in unsheltered premises (14.9% DM). Apart from the CP content, there is no significant difference in the chemical composition and nutritional value between cowpea hays kept in sheltered premises and those kept in unsheltered premises.

Chemical composition and nutritional values of dual-purpose sorghum fodder according to storage practices

Table 5 shows that the trends in the evolution of the nutritional values of Sorghum var. *Grinkan* following storage methods are quite similar to those of Cowpea tops var. *KVX 745-11p*. Indeed, the crude protein (CP) contents and the digestibility rate of organic matter of green fodder are significantly higher than those of stored stems. Also, the dry matter and fiber contents (except lignin) of the green fodder of Sorghum var. *Grinkan* are significantly lower than those of the stems stored in these nutrients.

Under storage conditions, the CP content of sorghum fodder stored in sheltered premises (6.6% DM) is significantly higher than that of fodder stored in unsheltered premises (4.5% DM). Apart from the CP content, there is no significant difference in the chemical composition and nutritional value between sorghum fodder stored in sheltered premises and those stored in unsheltered premises.

DISCUSSION

The results of the study show that extensive dairy farmers in western Burkina Faso use several types of storage infrastructure to preserve their fodder. These mainly include haylofts, stores, huts, storage on racks below sheds, etc. The use of storage infrastructures such as haylofts, stores and storage on racks below sheds would result from the impact of various awareness-raising and training activities aimed at these actors. These awareness-raising activities were carried out as part of the network of multi-actor milk innovation platforms. Producer-based organizations and more particularly innovation platforms offer frameworks conducive to the adoption of technologies, good practices and innovations in the agricultural world (Toillier *et al*., 2013; Toillier *et al*., 2015; Dabire *et al*., 2017; Audouin *et al*., 2021). As part of the Africa Milk Project which aimed to improve the supply of local milk to dairy processing units

Table 4: Nutritional values of green fodder and cowpea hay KVX745-11p depending on storage practices

Variables	Green fodder	Storage Condition		Sign
		Sheltered premises	Unsheltered premises	
MS (% MB)	92,61 ± 0,1^{a}	93,7 ± 0,6^{b}	93,5 ± 0,1^{b}	*
MM (% MS)	11,43 ± 0,1^{a}	7,4 ± 0,7^{b}	7,6 ± 0,3^{ab}	*
NDF (% MS)	42,81 ± 0,8^{a}	49,1 ± 3,2^{b}	50,5 ± 1,4^{b}	*
ADF (%MS)	33,76 ± 0,8^{a}	35,8 ± 2,7^{b}	37,1 ± 0,7^{b}	*
ADL (%MS)	6,016 ± 0,2^{a}	6,8 ± 0,5^{b}	7,1 ± 0,3^{b}	*
CP (% MS)	20,11 ± 0,2^{a}	16,0 ± 0,7^{b}	14,9 ± 0,3^{c}	*
EM (MJ/kg MS)	8,59 ± 0^{a}	8,5 ± 0,3^{a}	8,4 ± 0,1^{a}	NS
dMO (% MO)	61,20 ± 0,4^{a}	59,2 ± 2,3^{a}	57,8 ± 0,5^{a}	NS

Table 5: Food values of green fodder and stored fodder of Sorghum var. Grinkan based on Storage practices

Variables	Green fodder	Storage Conditions		Sign
		Sheltered premises	Unsheltered premises	
MS (% MB)	93,3 ± 0,1^{a}	95,2 ± **0,2**^{b}	95,0 ± **0,1**^{b}	*
MM (% MS)	8,5 ± 0,1^{a}	6,1 ± **1,5**^{ab}	5,2 ± **0,1**^{b}	
NDF (% MS)	67,2 ± 0,6^{a}	72,2 ± **1,4**^{b}	72,4 ± **0,3**^{b}	*
ADF (%MS)	38,9 ± 0,4^{a}	43,5 ± **4,4**^{b}	42,8 ± **0,6**^{b}	*
ADL (%MS)	4,1 ± 0,1^{a}	5,0 ± **1,1**^{a}	5,0 ± **0,3**^{a}	NS
CP (% MS)	7,9 ± 0,5^{a}	6,6 ± **0,7**^{b}	4,5 ± **0,2**^{c}	*
EM (MJ/kg MS)	7,5 ± 0,0^{a}	7,1 ± **0,4**^{a}	7,0 ± **0**^{a}	NS
dMO (% MO)	51,6 ± 0,3^{a}	45,9 ± **3,3**^{b}	45,8 ± **0,2**^{b}	*

Legend : *MB = raw material; DM = dry material; MM = mineral material; CP= Crude protein; EM = metabolizable energy, BMD = digestibility of organic matter; ADF = Acid detergent fiber; ADL = Acid Detergent Lignin; NDF = Neutral Detergent Fiber; Sheltered premises (hut/hayloft/store/under shed/on covered shed); Unsheltered premises = shed placed under tree/on tree/on shed without covering. * = Significant; NS = not significant, Values followed by the same letter are not significantly different at the 5% threshold*

through the co-design of technical and institutional innovation in the links of milk production and collection in Africa, the Volunteer test farmers were made aware of good practices for storing fodder after harvest. They were encouraged to build equipment suitable for good conservation of fodder. This is also what encouraged some of them to build sheds under which they made racks and stored the harvested fodder. However, it should be noted that storing fodder in sheds (without covering them) or on tree branches as described by Savadogo *et al.* (1999), remains the most frequently encountered practice. These practices persist despite the context marked by the interventions of projects and actors who support extensive dairy farmers to improve the milk productivity of farms. It should be noted that these interventions seem to be limited to awareness-raising actions and training in good practices without significant support in the creation of adequate livestock feed storage infrastructure. However, the construction of well-adapted and sustainable infrastructure such as stores and haylofts requires investments that are unbearable for small farmers. The construction of storage devices with local materials at the end of the winter season is one of the most suitable solutions but depends on the availability of labor and collaboration with the technical services in charge of protecting the environment.

In agropastoral and especially peri-urban areas, the majority of the family workforce is made up of pupils and students, which leads to a scarcity of workers at the end of the winter due to the resumption of the school year (Dabiré and Fayama, 2014). The harvesting of wood for the construction of sheds and other infrastructures very often constitutes sources of conflict between farmers and agents of environmental protection services. All these factors seem to force a large number of farmers (45%) to store hay in simple sheds and in tree branches. These ineffective practices contribute to deteriorating the quality of stored fodder, as revealed by the results of the sensory assessment and then the SPIR analyses.

The results of the visual assessment of the quality of the fodder stored showed that the fodder stored in sheltered premises (haylofts, huts, stores, under sheds, etc.) remained of very good to good quality while the fodder of poor quality (fair, poor) were found in unsheltered premises (on shed without cover, on tree, etc.). Indeed, the majority of hay from sheltered premises protecting against bad weather presented the characteristics of good hay, namely green to greenish color, pleasant odor, soft folds, absence of dust, etc. Fodder stored openly (in a shed without a cover, on a tree, etc.) without any protection tends to have a yellow or gray color, a burning smell and is covered with significant layers of dust which are characteristic of poor-quality hay. The greenish coloring of the hay indicates good harvesting, conservation and storage conditions, while the yellowish coloring reflects the exposure of the forage to bad weather and the sun (Le Manse *et al.*, 2018). Conversely, browned hay is often a sign of poor storage or bad weather at harvest (Sollio Agriculture, 2023). The results obtained from the sensory assessment of the fodder were confirmed by the NIRS analysis of the samples taken. If it is further tested through co-construction work with the diversity of animal feed stakeholders, it can constitute a simple technique for identifying good quality hay that can be distributed to farmers due to its relative accessibility.

The results of the SPIR analyzes show that the deterioration of both sorghum and cowpea fodder when moving from sheltered to unsheltered premises mainly concerns the crude protein composition. This is all the more logical when we know that nitrogen is sensitive to solar rays (Lawal *et al.*, 2017) and that the first bad weather to which fodder stored in sheds and trees are exposed is the sun. So, even if the storage method on sheds, on the roofs of houses and on trees is described as excellent in the absence of rain (Suttie, 2004), these practices can be considered bad in view of the significant reduction protein levels in the fodder due to weather. However, it should be noted that the quality of stored fodder does not depend exclusively on storage conditions; other parameters ranging from the harvest stage to packaging practices and drying conditions must be considered.

CONCLUSION

This study made it possible to document the deterioration of the nutritional value of dual-use sorghum and cowpea fodder when they are stored in premises not sheltered from bad weather. It showed that the protein composition was particularly reduced when cowpea tops and sorghum straws were exposed on trees, on sheds or on the roofs of houses. However, the use of these storage conditions remains common in rural areas in West Africa, particularly in small family dairy farms. So that the latter can make the most of their animal production workshops in the dry season (meat and milk), they should be made more aware of good storage practices for cultivated fodder and crop residues which best preserve their nutritious values. Better still, development programs and projects should, beyond raising awareness for the benefit of small family dairy farms, include structuring investments including suitable infrastructures for storing fodder after harvest.

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