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Bromatological Analysis of the Fodder Marketed in the Peri-Urban Areas of Bujumbura (Burundi): Towards Spontaneous Fodder Conservation by Transformation into Silage

*Joseph Butore, Daniel Sindaye, Mathias Hitimana,
Jacques Nkengurutse and Tatien Masharabu*

Abstract

Peri-urban areas of Bujumbura host a significant number of dairy cattle, which consequently ensure a substantial production of milk consumed in the Burundian capital. The presence of these cows in peri-urban areas has led to the emergence of an atypical market for spontaneous forage species. The present study seeks to determine the food and nutritional value of this fodder. A test on its conservation by transformation into silage was also carried out. Botanical field investigations and plant samples collection were carried out under the guidance of fodders suppliers. Based on the bromatological value deficiency thresholds for cattle, the results showed that the content of digestible nitrogenous matter and major elements (Ca, P, K, and Mg) in the forage is within acceptable limits. The final product obtained after fermentation, based on its color, its smell, and its consistency, is indeed silage. The chemical composition of fermented fodder showed that the nutritional quality has remained almost the same. Further research on digestibility of this forage is necessary. A study of the environmental determinants of spontaneous forage distribution at multiple sites and over a wide range of parameters may contribute to a better understanding of the importance of this fodder particularly in times of fodder deficit.

Keywords: Anaerobic fermentation, animal feed, floristic composition, forage, silo

1. Introduction

Buringa and Maramvya localities in peri-urban neighbourhoods of Bujumbura City (Burundi) house many dairy cow heads. Therefore, this ensures a significant production of milk consumed in the Burundian economic capital. In the past, this breeding was practiced either in the capital Bujumbura, in the Rusizi National Park -Palm Area (Rukoko), or other areas surrounding Bujumbura. As a result of the administrative and environmental protection measures, these cows have been

moved to the peri-urban areas of Bujumbura, where it is sometimes difficult to find enough and sustainable feed for livestock.

The presence of these cows in the peri-urban areas of Bujumbura has led to the creation of a market for forage species to feed these animals. The reasons for the set-up of this new type of market include the fact that along the Rusizi River is the Rusizi National Park, where it is strictly forbidden to graze the herds, the proximity to Melchior Ndadaye International Airport, and plots of the Regional Development Corporation of Imbo (SRDI) for rice growing, etc.

This market system addresses the problem of grazing. It is so new and unusual in Burundi. However, it is a business that sustains the livelihood of a Sample of people and contributes to the development of the country. It is with this business that the city of Bujumbura is supplied (in part) with milk. However, the food and nutritional value of these plant species need to be documented as well as the socio-economic aspects of this trade.

Indeed, it is only in the peri-urban areas of the city of Bujumbura, where this type of business exists while livestock farming is practiced throughout the country. Again, those who trade are not native to the region in question. They come from different provinces of the country including Ngozi with a workforce of about 68% of sellers of this forage market of Buringa [1]. Thus, the present study seeks to determine the nutritional value of these fodders through an analysis of their bromatological value, firstly. Secondly, spontaneous fodder marketed at the Buringa market having already been described and characterized [2], their regular use confirmed by local breeders [1]. In addition, a test on their conservation by transformation into silage was also carried out in this study with a view to improve animal feed, and above all contributing to the sustainable use of this spontaneous fodder.

The socio-economic aspects of this new type of livestock and trade will be addressed in other publications.

2. Material and methods

2.1 Material

2.1.1 Study area

2.1.1.1 Buringa and Maramvya areas

The exploratory study was conducted at the Buringa fodder market (**Figure 1**) in the peri-urban area of Bujumbura. The sampling of forage plants studied has been carried out in the Buringa and Maramvya areas, located in Gihanga commune of Bubanza province, and Mutimbuze commune of Bujumbura province. **Figure 2** showing the sampling area was generated using the QGIS Desktop 2.18.11 software. These areas are crossed by the National Road Nr 5 (RN 5). A seven-kilometer distance separates Melchior Ndadaye International Airport from the Buringa Forage Market. They are all part of the Imbo Plain [3]. The natural region of Imbo is characterized by a low altitude of about 1000 m and warm weather. This region is made up of the plain of Rusizi and the coastal plain of Lake Tanganyika. It is between 2°45' and 4°27' South latitude and 29° and 39°40' East longitude. The plain is bounded by two major horsts: the watershed of the Basins of the Congo and the Nile and the Itombwe massif, which borders the plain to the west in DR Congo. These mountains peak respectively at 2600 m and 3200 m of altitude. This particular situation, in an overheated basin and the south-east trade wind that crosses it further accentuates the semi-arid climate that characterizes it [4].



Figure 1.
Partial view of Buringa fodder market located in Gihanga commune of Bubanza province, Burundi.

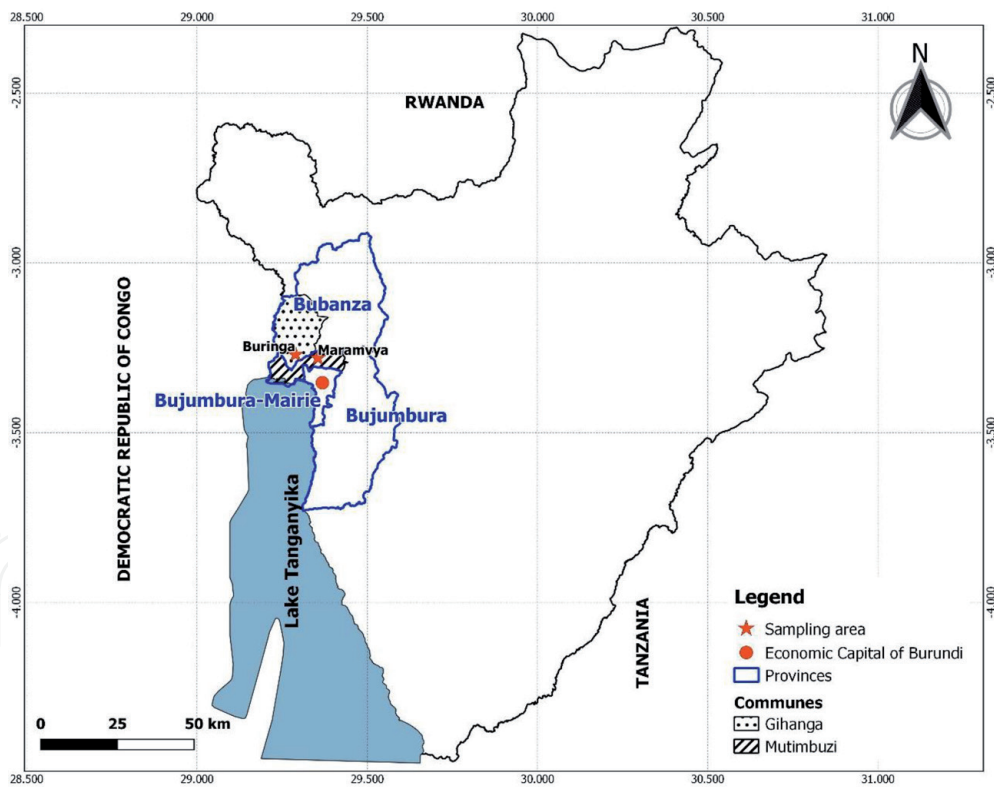


Figure 2.
Location of Buringa and Maramvya fresh fodder markets, located respectively in Gihanga commune of Bubanza province, and Mutimbuzi commune of Bujumbura province, Burundi.

2.1.1.2 Nyabunyegeri pisty and its facilities

The pigsty (**Figure 3**) in which the spontaneous anaerobic fodder fermentation experiment was carried out is on Nyabunyegeri hill in Mutimbuzi commune. This pigsty started its activities in 2016 and during our stay, it had around 150 pigs divided into different categories (suckling sows, gestating sows, empty sows, growing piglets, fattening pigs and boars).



Figure 3.
Partial view of Nyabunyegeri pisty, Burundi.



Figure 4.
The silo used during the experiment at Nyabunyegeri pigsty, Burundi.

The Nyabunyegeri pigsty has a few silos that are regularly used for anaerobic fermentation of herbs, wastes of seasonal fruits and other vegetables used in animal feed. One of these silos was used for our experiment (**Figure 4**).

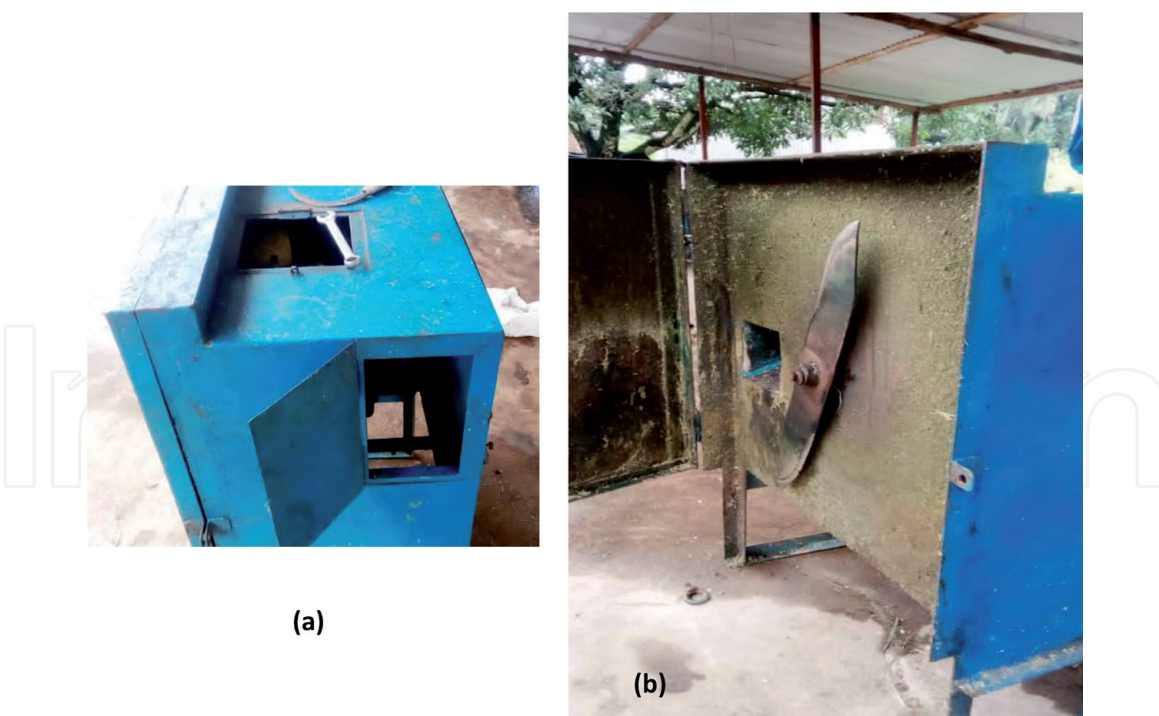


Figure 5.
 Partial view of the chopping machine brand ITARA-M 9186/BI. (a) Outside view and (b) Chainsaw part.

The silo has a cylindrical shape with 0.5 m internal diameter; 0.6 m high with an almost smooth internal wall where there was no need to use cling film to ensure waterproofing except for the roof; volume 11.775,000 Cm^3 . All parts of the silo are made of reinforced concrete, with a cylindrical wall 11 Cm thick; a heavy and circular cover which properly close the walls. The base of this small structure, but whose dimensions are well adapted to this type of experiment, was equipped with a few small pipes allowing the effluent to be released to the outside of the silo.

In the pigsty, the fodder chopping is carried out using a chopping machine brand ITARA- M 9186/BI (**Figure 5**) manufactured by young burundians grouped together in a cooperative called Cooperative of Innovation and Reflection for Integrated Development (CIRDI: Coopérative d'Innovation et de Réflexion pour le Développement Intégré).

2.1.2 Other material used

A bicycle for the transport of the fodder to be fermented (**Figure 6**), cooking salt (NaCl), molasses from sugar cane produced by the Mosso Sugar Factory (SOSUMO) located in Eastern Burundi in the Province of Rutana, 16 piglets in growth aged three months on which palatability was tested, and a camera.

The following equipment was used for the various analyzes carried out at the Agricultural Chemistry Laboratory of the Institute of Agronomic Sciences of Burundi (ISABU):

- The humidity/dry matter (crude and analytical) was analyzed with the following devices: analytical balance to within 1/10,000, an oven set at 105°, an appropriate crucible;
- The total ash at 600°C was determined using: an analytical balance, a porcelain capsule, an oven set at 600°C.



Figure 6.
Three bunches (batches) of a mixture of fresh fodder used for fodder conservation test by transformation into silage.

- The quantity of total phosphate was calculated using the following device: a mineralizer, UV-visible.
- The protein contents were analyzed using: nitrogen mineralizer (Kjeldahl), Kjeldahl tube, digital burette, nitrogen still.
- The minerals Ca, Mg and K were calculated using: mineralizer, SSA, analytical balance.
- Crude cellulose (fibers) was analyzed using as devices: a hot plate, a refrigerator, a fiber extractor, an analytical balance.
- An analytical balance and a separating funnel were used for the analysis of the fat.

2.2 Methodology

2.2.1 Floristic composition and bromatological value

Collection of forage samples was made in the Buringa Zone of Gihanga Commune in Bubanza Province and the Maramvya Zone of Mutimbuzi Commune in Bujumbura Province under the guidance of fodders suppliers. The collection of samples can be described as follows: with the guide (a seller), we walked and when we arrived at the site of collection, he cut the grass as usual and put them at our disposal. Then, we reviewed all the species constituting the sample he handed to us. We took a small pile of 150–200 grams which was later subjected to analysis of the bromatological value. Three sites considered for having a relative high production of forage marketed in the fodder market had attracted our attention. These sites

were rice plots, Mpanda cemetery and its surroundings, and the level curves. In each site, three forage samples were collected at different localities and in total nine forages samples were taken for bromatological analysis.

The database of flowering plants of tropical Africa [5] put online by the Conservatory and Botanical Garden of the City of Geneva and South African National Biodiversity Institute, Pretoria (African Flowering Plants Database version 3.3.4, <http://www.ville-ge.ch/musinfo/bd/cjb/africa/>) was consulted to check the nomenclature of species and families.

The analyses of the bromatological value of the forage batches were carried out in the Soils and Agro-Food Products Analysis Laboratory (LASPA) of the ISABU. The parameters analysed as follows:

- raw dry matter (DM) in % and analytical DM in % was analyzed using the gravimetric method at 105°C.
- fat in % DM was analyzed using the gravimetric method (petroleum ether extraction).
- protein in % DM was analyzed using the standardized method (ISO 11261, Modified Kjeldahl method, volumetric assay).
- crude cellulose in % DM was analyzed using WEENDE method (gravimetric method, attack by acid + soda).
- phosphorus in mg/kg DM was analyzed using the vanado-molybolic complex method by Ultra-Violet spectrophotometry, after mineralization (dry and with acid).
- potassium in mg/kg DM, Calcium in mg/kg DM and Magnesium in mg/kg DM were analyzed with the spectrophotometric atomic absorption (SSA) /flame assay method after dry and acid mineralization.

Nine samples from nine different sites were analyzed.

2.2.2 Anaerobic fermentation of spontaneous forages at Nyabunyegeri pigsty

The sample used to carry out a test on the fodder conservation by transformation into silage consisted of 3 bunches of a mixture of fresh forages dominated by Poaceae. The fodder used for this test was bought at the Buringa market, and transported by bicycle to Nyabunyegeri hill in the neighboring Commune of Mutimbuzi in Bujumbura province where there is a pigsty with vertical silos within it, regularly used in the manufacture of silage. One of the silos was used to conduct this experiment.

The fodder chopping was carried out using a chopping machine brand ITARA- M 9186/BI.

It should be noted that the fodder used was fresh, therefore, purchased, chopped, and fermented on the same day. The chopper had been set to cut the forage into 1 cm segments to meet the chopping dimensions at this host farm.

Always to comply with the practices of the host pigsty, cooking salt and molasses (were added to the chopped forages before fermenting them. These two products were added with respective doses of 1 kg and 2 kg per 100 kg of chopped fodder. The salt and molasses were first mixed separately, before being gradually incorporated into the chopped fodder during the various stages of compaction when filling the silo.

The compaction was done gradually and in two complementary ways, always following the practices of this farm in the fermentation of plants for pigs. First, the farm workers dipped their feet in boots (carefully washed first) in the silo to pack the fodder to ferment, layer by layer, jumping on the chopped fodder. Then the heavy silo cover was used and placed on the top layers inside the silo as well; this is to have a perfect settlement, that i.e. to completely expel the air from the biomass in order to guarantee anaerobic fermentation. The same cover was put on the silo at the end to close it tightly with its content.

Once cut and mixed with the molasses + salt solution, a sample of the fodder was analyzed at the same laboratory of ISABU in order to assess the biochemical composition of this type of food before fermentation. Another sample was taken from the finished product to undergo the same analyzes in the same laboratory, with the same methods, in the aim of determining possible changes in nutritional value.

The metabolizable energy was calculated using a formula provided by the same laboratory:

$$\text{Metabolizable energy in Kcal / kg of dry matter} = 3951 + 54.4 \times \text{fat} - 88.7 \times \text{fibers} - 40.8 \times \text{ash} \quad (1)$$

The palatability test [6, 7]. was conducted on pigs since the test was carried out in a pigsty where animals were fed with similar feed (but made from other types of forages) and on a regular basis. Thus, 6 kg of chopped fodder was taken from the mass to be fermented and distributed to 16 piglets aged three months. Once the silage was ready, i.e. 3 days after storage and closing the silo, the palatability test was repeated on the same piglets.

2.2.3 Statistical analysis

In order to assess the degree of similarity of forage samples in terms of presence-absence of the species, a dendrogram (Cluster analysis) was subsequently generated using the MVSP 3.1 software (Multi-Variate Statistical Package) with the Jaccard coefficient [8].

One-way ANOVA following Duncan's multiple ranges test (SPSS programming toll, IBM SPSS. 25) was performed to test whether within the rice plots, Mpanda cemetery and its surroundings, and the level curves, the bromatological value of the batches of forage samples collected differ significantly.

3. Findings

3.1 Floristic composition of analyzed samples

The analysis of the bromatological value included 9 batches of samples gathered from 9 collection sites. These 9 batches consisted of 5 to 11 species each one; 20 species in total including two undetermined species. The Poaceae family has 15 species. The five remaining species are families of Commelinaceae (2), Convolvulaceae (1), Portulacaceae (1), and Euphorbiaceae (1). **Annex 1** shows the floristic composition of each batch which has been subject of a bromatological analysis. No species of the family of the Fabaceae were recorded and analyzed. *Commelina diffusa* L. (Commelinaceae) and *Leersia hexandra* Sw. (Poaceae) occur in almost all batches analysed. This could provide information on their relative abundance in the study area. **Figure 7** illustrates the degree of similarity between the nine batches of forage

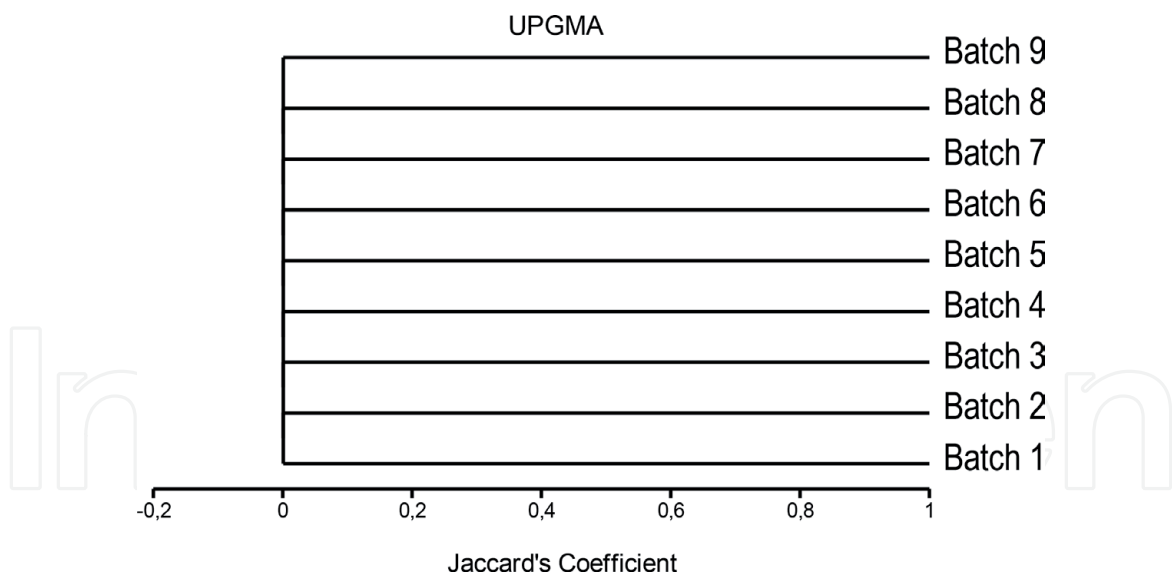


Figure 7.
Floristic affinities among the nine batches of forage samples collected in Buringa in Gihanga Commune and Maramvya in Mutimbuzi Commune (Burundi). Batch 1: Village 6 Gihanga, on rice dykes, Batch 2: Rubira/ Mpanda, Batch 3: Rukaramu- Mutimbuzi Commune, Batch 4: Gihanga-Rukoko 1, Batch 5: Gihanga-Rukoko 2, Batch 6: Mpanda Cemetery, Batch 7: in the premises of SRDI (Imbo Regional Development Corporation) headquarters, Batch 8: Rukaramu 2, Batch 9: Maramvya, on the edge of the irrigation canal of rice fields near a road.

samples in terms of presence-absence of species: there is no significant difference in terms of floristic composition.

3.2 Bromatological value of the fodder studied

The bromatological value of the fodder sold is not the same depending on their origin. The bromatological value analysis of the fodder is therefore very important for understanding its quality. The **Table 1** shows the nutrients composition of fodder from 3 different sites: rice plots, Mpanda cemetery and its surroundings, and the level curves. There was a significant difference ($p < 0.05$) both in crude fat and crude fiber. Likewise, none of the prospected sites produces a forage richer and more balanced in all nutrients compared to the other sites.

Item	Rice plots	Mpanda Cemetery	Level Curves	p-value
Crude DM %	78.11 ± 1.48	79.00 ± 1.64	77.33 ± 1.61	0.768
Analytical DM in %	94.08 ± 0.82	93.58 ± 0.73	94.26 ± 1.71	0.915
Crude Fat % in % DM	2.74 ± 0.12	2.64 ± 0.23	3.37 ± 0.98	0.03*
Crude Proteins % in % DM	18.09 ± 2.91	12.74 ± 1.22	17.04 ± 1.63	0.229
Crude fiber % in % DM	26.40 ± 0.68	28.69 ± 1.12	25.70 ± 0.42	0.085*
P in mg/kg DM	3144.66 ± 484.37	2860.00 ± 63.37	3034.33 ± 310.04	0.836
K in mg/kg DM	26156.33 ± 2905.08	29499.00 ± 2015.93	23057.00 ± 643.80	0.170
Ca in mg/kg DM	4246.33 ± 476.66	4925.66 ± 429.21	3950.00 ± 188.35	0.263
Mg in mg/kg DM	2403.33 ± 159.21	3519.33 ± 593.50	2483.00 ± 312.06	0.167

Table 1.
Bromatological value of the batches of forage samples collected at Buringa and Maramvya fresh fodder markets, respectively in Gihanga and Mutimbuzi Communes, Burundi based dry matter (DM) (DM: Dry Matter).

3.3 Food and nutritional value of spontaneous forage before and after anaerobic fermentation (direct silage)

The assessment of the food and nutritional value of the spontaneous fodder used was carried out in two stages: before and after anaerobic fermentation. **Figure 8** shows the forage ready to be fermented under anaerobic conditions; and **Figure 9** shows the forage resulting from the anaerobic fermentation. Initially, the forage was green in color. After fermentation, the color was yellow-brownish, a pleasant smell with a scent of molasses, and the fodder pieces separated easily from each other.

The results of the chemical composition analysis of the sample of fodder cut and mixed with the molasses + salt solution before fermentation, as well as that of another sample which was taken from the finished product (silage) is shown in **Table 2**.

3.4 Metabolizable energy

By applying the formula provided by ISABU, the metabolizable energy found for unfermented fodder was:

$$3951 + 54,4 \times 1,84 - 88,7 \times 32,5 - 40,8 \times 11,5 = 699.146 \text{ kcal / kg of dry matter} \quad (2)$$

For fermented fodder, the metabolizable energy is as follows:

$$3951 + 54,4 \times 1,26 - 88,7 \times 26,9 - 40,8 \times 17,2 = 931.754 \text{ kcal / kg of dry matter} \quad (3)$$



Figure 8.
Chopped fodder ready for fermentation.



Figure 9.
Fermented fodder when the silo is opened (clearly visible brownish-yellow color).

Sample	Forage cut and mixed with the molasses + salt solution before fermentation	Final product after fermentation (Silage)
Laboratory Number	K 481	K 482
Raw Dry Matter (DM) %	24,2	22,7
Analytical DM in %,	98,4	97,9
Fat in % DM	1,84	1,26
Total ash in % DM	11,5	17,2
Proteins in % DM	7,73	8,44
Crudes fibers in % DM	32,5	26,9
Magnesium in mg/kg DM.	2660	2513
Calcium in mg/kg DM	2891	8864
Potassium in mg/kg DM	25104	19374
Total Phosphorus in mg/kg DM	171	160

Table 2.
Chemical composition of a sample of forage cut and mixed with the molasses + salt solution before fermentation (K 481), as well as that of another sample that was taken from the finished product after fermentation (K 482). DM: Dry Matter.

3.5 Palatability test

The 6 kg of chopped fodder which was taken from the quantity to be fermented was completely consumed by 16 three-month-old piglets in 25 minutes. For the ready silage, i.e. 3 days after storage and closure of the silo, the same amount of feed

was this time consumed by the 16 young pigs in 28 minutes. It should be noted that no discomfort was observed in any of these animals after consuming both types of feed, one from chopped fodder ready for fermentation, and the other from the silage itself.

4. Discussion

4.1 Floristic composition of forage samples

The degree of similarity among the nine samples of forage samples in terms of presence-absence of the species does not suggest a significant difference. However, the nutritional value of the forage sold is not the same (**Table 1**). The bromatological value of forages varies according to several parameters including the richness of the soil in fertile elements, the vegetative stage of the plant, and the mode of preservation of the fodder (fresh or preserved) [9].

Given that the consideration of several environmental variables is likely to increase the explained floristic variability [10, 11], a study of the environmental determinants of the distribution of spontaneous forages at several sites and on a varied range of parameters is to consider. In fact, in nature, environmental factors (biological, physical, historical, etc.) do not act in isolation: they can influence one another or in synergy. Other factors that are difficult to quantify and dissociate, such as climatic fluctuations, chance, mortality, inter- and intraspecific competition, predation, geographical barriers to the spread of plant diaspores, dispersal agents, substrate, etc. may also interfere [12].

4.2 Bromatological value of forage samples

It was observed a significant difference ($p < 0.05$) both in crude fat and crude fiber. Except Phosphorus (P) composition which is relatively high in rice plot and level curves, the forage from Mpanda cemetery and its surroundings had a relative high composition in Potassium (K) Calcium (Ca), and Magnesium (Mg). In line with that, many researches had shown many factors which are responsible for the spontaneous species nutritional value composition. These include soil factors, such as soil pH, available nutrients, soil texture, organic matter content and soil-water relationships, weather and climatic factors, the crop and cultivar, postharvest handling and storage, and fertilizer applications and cultural practices [13–17].

Based on the bromatological value deficiency thresholds for cattle, the results show that the content of digestible nitrogenous matter (DNM) and major elements (Ca, P, K, and Mg) in the forage is within acceptable limits. The mineral content is greater than 0.26% Ca, 0.18% P, 0.60% K and 0.10% Mg/kg DM, and the DNM content is greater than 25 g/kg of DM [18].

The specific differences observed in the indicators of the bromatological value of the fodder sold at the Buringa fodder market would be linked to the nature of the soil and to the activities taking place regularly on each site. But it should be noted that the average quantities found, indicator by indicator, fall within the range of biochemical standards for green feed for animals [19].

There is always compensation and supplementation. The farmers mix forage from different localities or associate them with some concentrates for livestock,

which increases the fodder quality. Burundian breeders traditionally provide a mineral supplement to livestock from mostly the Imbo saline soils (Icuhiro) [20]. These salty soils can ultimately correct sodium deficiency and meet the calcium and magnesium requirements of livestock. Then, the deficiency in some mineral elements of the forage is compensated by these salty soils.

4.3 Assessment of the food and nutritional value of spontaneous fodder before and after fermentation (direct silage): towards fodder conservation by transformation into silage of spontaneous fodder

For the sample of unfermented spontaneous fodder, the data in **Tables 1** and **2** are very close. This is because the spontaneous fodder used came from the same region. After fermentation, a slight decrease was observed for the following indicators: dry matter, fat, raw fiber, Magnesium, and Phosphorus. A small increase was observed for protein.

The sound variations were observed for the total ash for which the content went from 11.5% to 17.2%; and Calcium, for which the quantity tripled from 2891 mg/kg of dry matter to 8864 mg/kg of dry matter. Similar changes in mineral content have also been reported by Agence Française de Sécurité Sanitaire des Aliments, AFSSA [21].

4.4 Metabolizable energy

The metabolizable energy found for unfermented forages was 699.146 kcal/kg of dry matter while for fermented fodder it was 931.754 kcal/kg of dry matter.

This increasing trend of metabolizable energy would be a combined consequence of mastering good storage conditions by fermentation, plus the influence of added silage agents (molasses).

But it should also be noted that growing piglets need more metabolizable energy [19] which our fermented fodder cannot provide on its own; hence the need to supplement it with other types of feeds more rich in energy.

4.5 Palatability

A relative decrease in appetite for fermented forage was observed in this study. This relative decrease in palatability is also mentioned by AFSSA [21] which specifies that with rare exceptions, the ingestibility of fodder stored as silage is lower than that of the corresponding green fodder. The 3-day waiting period after storage and closing the silo were considered to meet the time usually observed in this pigsty during the fermentation of fodder. It should be noted that no discomfort was observed in any of these animals after consuming both types of feed, one from the chopper fodder before fermentation and the other from the silage itself. It was this encouraging observation, moreover, that led us to distribute to the piglets the entire quantity of the fermented fodder up to the end. Finally, it should be noted that in comparison with the silage prepared previously in this pigsty, it is the one resulting from our experiment that the piglets ate more quickly, i.e. 6 kg in 28 minutes for 16 piglets against 31 minutes for the same quantity of silage, and the same number of growing piglets.

Our results on the palatability test are similar to those of other studies [22, 23] who confirmed that the aroma of molasses improves food consumption by swine species.

5. Conclusion

This study focused on the assessment of the bromatological value of the fodder traded in Buringa, in peri-urban areas of the city of Bujumbura, Burundi. A test on their conservation by transformation into silage was also carried out in this study with a view to improve animal feed, and above all contributing to the sustainable use of these fodder.

Given that from a qualitative point of view stating that the bromatological value of the fodder sold at the fodder market is not the same (DM, Protein, Fat, Mineral matter), it is possible for a breeder to choose a fodder supplier site for his livestock taking into account the specific needs of the animals.

It was observed that the fodder content in minerals is relatively high. This is explained by the fact that the soil of the Imbo plain is generally saline [20]. Finally, the overall quality of the fodder is good although the nutritional value of each forage species sold, and considered individually, has not been documented.

Organoleptically speaking, the final product obtained, based on its color, its smell and its consistency, is indeed silage. The chemical composition of the product (fermented fodder) indicates that the nutritional quality has remained almost the same. The stored food is well palatable by the animals. Finally, the conservation of spontaneous Buringa fodder by anaerobic fermentation makes feasible the sustainable use of this feed in the farm without compromising its food and nutritional value.

Further research on digestibility of this forage is necessary. Moreover, a study of the environmental determinants of spontaneous forage distribution at multiple sites and over a wide range of parameters may contribute to a better understanding of the importance of this fodder particularly in times of fodder deficit.

Acknowledgements

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Annex 1:

Floristic composition of the nine batches of forage samples collected from Buringa in Gihanga Commune and Maramvya in Mutimbuzi Commune (Burundi), and subjected to bromatological analysis. These samples represent the forage traded in Buringa (+: Presence, -: Absence). Sample 1: Village 6 Gihanga, on rice dykes, Sample 2: Rubira/Mpanda, Sample 3: Rukaramu-Commune Mutimbuzi, Sample 4: Gihanga-Rukoko 1, Sample 5: Gihanga-Rukoko 2, Sample 6: Mpanda Cemetery, Sample 7: Sample 7: in the premises of SRDI (Imbo Regional Development Corporation) headquarters Sample 8: Rukaramu 2, Sample 9: Maramvya, on the edge of the irrigation canal of rice plots near a road.

Family	Species/Batch samples	1	2	3	4	5	6	7	8	9
Commelinaceae	<i>Commelina diffusa</i> L.	+	+	+	—	+	—	+	+	+
	<i>Commelina africana</i> L.	—	—	—	+		+	—	—	—
Convolvulaceae	<i>Ipomoea aquatica</i> Forssk.	—	+	—	+	—	—	—	+	+
Euphorbiaceae	<i>Euphorbia</i> sp.	+	—	—	—	—	—		—	—
Portulacaceae	<i>Portulaca oleracea</i> L.	+	—	—	—		—	—	+	—
	<i>Cynodon nlemfuensis</i> Vanderyst	—	—	+	+	+	+	+	—	+
	<i>Digitaria abyssinica</i> (Hochst. ex A. Rich.) Stapf	—	—	—	—	—	+	—	—	—
	<i>Echinochloa pyramidalis</i> (Lam.) Hitchc. & Chase	—	—	—	+	—	—	—	—	—
	<i>Eriochloa meyeriana</i> (Nees) Pilg.	—	—	—	+	—	+	—		—
	<i>Indet.1</i>	—	—	+	—	+	—	+	—	—
	<i>Indet.2</i>	—	—	—	+	—	—	—	—	—
	<i>Leersia hexandra</i> Sw.	+	+	+	+	+	—	+	+	+
	<i>Oryza longistaminata</i> A. Chev. & Roehr.	+	+	—	+	—	—		+	+
Poaceae	<i>Panicum maximun</i> Jacq.	—	—	—	—	—	—	+	+	+
	<i>Panicum trichocladum</i> Hack. ex K. Schum.	—	—	—	+	+	+	+	—	—
	<i>Paspalidium germinatum</i> (Forssk.) Stapf	—	—	+	—	—	—	+	—	—
	<i>Pennisetum purpureum</i> Schumach.	—	+		+	—	—	—	—	—
	<i>Pseudobromus silvaticus</i> K. Schum.	—	—	—	—	+	+	—	—	—
	<i>Setaria homonyma</i> (Steud.) Chiov.	—	—	—	—	—	+	—	—	—
	<i>Setaria longiseta</i> P. Beauv.	—	—	—	+	+	+	—	—	—
	Total	20	5	5	5	12	7	8	7	6

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Author details

Joseph Butore¹, Daniel Sindaye^{1,2}, Mathias Hitimana^{3,4}, Jacques Nkengurutse³ and Tatien Masharabu^{3*}

1 Department of Health and Animal Productions, Faculty of Agronomy and Bio-Engineering, University of Burundi, Bujumbura, Burundi

2 South China Agricultural University, Maoming Branch, Guangdong Laboratory for Lingnan Modern Agriculture, Guangdong Provincial Key Laboratory of Animal Nutrition Control, National Engineering Research Center for Breeding Swine Industry, College of Animal Science, Guangzhou, China

3 Faculty of Sciences, Research Centre in Natural and Environmental Sciences, University of Burundi, Bujumbura, Burundi

4 School of Life Sciences, Key Laboratory for Geographical Process Analysis and Simulation, Central China Normal University, Hubei Province, Wuhan, China

*Address all correspondence to: tatien.masharabu@ub.edu.bi

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References

- [1] Sindaye D. Etude sur le commerce du fourrage dans la zone périurbaine de Bujumbura: cas des zones Buringa et Maramvya. Mémoire d'Ingénieur Agronome, Université du Burundi ; 2016.
- [2] Masharabu T., Butore J., Sindaye D., Hitimana M. Diversité floristique et distribution potentielle des essences fourragères spontanées au Burundi. *Geo-Eco-Trop*; 2019: 43(1): 161-170.
- [3] Ministère de la planification du développement et de la reconstruction nationale. Monographie des communes Gihanga et Mutimbuzi. Bujumbura-Burundi; 2006.
- [4] Dewez J. La culture cotonnière dans l'Imbo. ISABU, Bujumbura; 1986.
- [5] Lebrun J.-P., Stork A.L. Enumération des plantes à fleurs d'Afrique tropicale et Tropical African Flowering Plants: *Ecology and Distribution*; 1991-2015: vol. 1-7. Conservatoire et Jardin botaniques de la Ville de Genève.
- [6] Forbes J.M. Palatability: principles, methodology and practice for farm animals. *Animal Science Reviews* ; 2010 : 239-250 in CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources; 2010: 5(052) : 1-15.
- [7] Baumont R. Palatabilité et comportement alimentaire chez les ruminants. *INRA Production Animale*; 1996: 9 (5) : 349-358.
- [8] Kovach W.L. MVSP: Multi-Variate Statistical Package data analysis. *Kovach Computing Services*; 85 Nant-y-Felin, Pentraeth, Anglesey; 1997.
- [9] Diouf A. Typologie des exploitations et étude de rentabilité des cultures fourragères dans les systèmes de production du Bassin arachidier du Sénégal. Mémoire d'Ingénieur AgroEconomiste. Ecole Nationale Supérieure d'Agriculture de Thiès; 2002.
- [10] Masharabu T. Flore et végétation du Parc National de la Ruvubu au Burundi: diversité, structure et implications pour la conservation. Editions Universitaires Européennes, Sarrebruck-Allemagne; 2012. 256 p.
- [11] Masharabu T., Noret N., Bigendako M.J., Godart M.-F., Lejoly J., Bogaert, J. Effects of Fabaceae cover on soil parameters and analysis of environmental determinants of floristic variability in North-Eastern Ruvubu, Burundi. *International Journal of Current Trends in Science and Technology*; 2011: 2(2): 113-124.
- [12] Lobo J.M., Castro I., Moreno J.C. Spatial and environmental determinants of vascular plant species richness distribution in the Iberian Peninsula and Balearic Islands. *Botanical Journal of the Linnean Society*; 2001: 73:233-253.
- [13] Widdig M., Heintz-Buschart A., Schleuss P. M., Guhr A., Borer E. T., Seabloom E. W., Spohn M. Effects of nitrogen and phosphorus addition on microbial community composition and element cycling in a grassland soil. *Soil Biology & Biochemistry*; 2020: 151.
- [14] Lenhart P. A. Using plant nutrient landscapes to assess Anthropocene effects on insect herbivores. *Current Opinion in Insect Science*; 2017: 23: 51-58.
- [15] Waldrop M. P., Holloway J. M., Smith D. B., Goldhaber M. B., Drenovsky R. E., Scow K. M., Dick R., Howard D., Wylie B., Grace J. B. The interacting roles of climate, soils, and plant production on soil microbial communities at a continental scale. *Ecology*; 2017: 98(7): 1957-1967.
- [16] Feng C. , Ai Y. , Chen Z. , Liu H., Wang K. , Xiao J. , Chen J., Huang Z.

Spatial variation of soil properties and plant colonisation on cut slopes: a case study in the semi-tropical hilly areas of China. *Plant Ecology & Diversity*; 2016: 9(1): 81-88.

[17] Moghadam F. S., Zimmer M. (2016). Effects of warming, nutrient enrichment and detritivore presence on litter breakdown and associated microbial decomposers in a simulated temperate woodland creek. *Hydrobiologia*; 2016: 770(1): 243-256.

[18] Sikumbili V., Mandiki S. Teneurs en éléments majeurs, Calcium, Potassium, Magnésium et Phosphore et valeur fourragère (énergie-protéines) des pâturages naturels de la sous-région pastorale de l'Ituri (République du Zaïre). *Tropicultura*; 1989 :7 (4) : 158-163.

[19] Khokhrin S.N. Study guide for higher educational institutions in 310800 "Veterinary Medicine"/editor TS Molochaeva; Moscow, 2007. Ser. Textbooks and teaching aids for students of university.

[20] Gourdin J., Tilquin J.P., Hollebosc P., Kibiriti C. Icuhiro, complément minéral utilisé dans l'élevage traditionnel au Burundi. *Tropicultura* ; 1989 : 7(2) : 52-54.

[21] AFSSA. Bonnes pratiques de fabrication de l'ensilage pour une meilleure maîtrise des risques sanitaires. Rapport technique; 2004.

[22] Laitat M., De Jaeger F., Vandenneede M., Nicks B. Facteurs influençant la consommation alimentaire et les performances zootechniques du porc sevré : perception et caractéristiques de l'aliment. *Annales de Médecine Vétérinaire* ; 2004 : 148 : 15-29

[23] McLaughlin C.L., Baile C.A., Buckholtz L.L., Freeman S.K. Preferred flavours and performance of weanling pigs. *Journal of Animal Science* ; 1983 : 56 : 1287-1293.