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RESEARCH ARTICLE **OPEN ACCESS**

ASSESSMENT OF THE NUTRITIONAL PROFILE OF "MARALFALFA" (PENNISETUM SP) ASSOCIATED WITH MOLASSES

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ABSTRACT

Introduction: The "*maralfalfa*" scientifically called *Pennisetum sp*, is a grass plant of the poaceous family used in livestock feeding. The objective of this study is to assess the nutritional profile of a "*maralfalfa*" based formulation associated with molasses used in Chad. ***Methodology:*** To carry out this study, "*maralfalfa"* samples were taken from the IRED experimental pool set up by the ACCEPT project. The molasses samples were acquired from Chad Sugar Company (CST). These samples were sent to the laboratories of the Food Quality Control Centre (CECOQDA) and the bromatology laboratory of the Breeding Research Institute for Development (IRED) for analysis. ***Results:*** Results showed that "*maralfalfa"* is a potential source of protein (8.39g/DM), fat (2.68%), carbohydrates (23.13g/DM) and minerals (14.17%). The dry matter content of "*maralfalfa*" forms the energy input of the nutritional requirements in the form of calories needed by the animals. Molasses is primarily an energy source because its carbohydrate content is (73g/DM). A NutriSurvey software analysis of the "*maralfalfa*" (700g) and molasses (100g) formulation yields a very appreciable protein value equivalent to 18%. ***Conclusion:*** The results of our various analyses have shown that the species *Pennisetum sp*, constitutes a potential source of energy. Its association with molasses would not only be an additional source of energy but also a real source of protein.

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INTRODUCTION

In arid areas, it is the pastoral systems on rangeland that predominate. Animal husbandry in its subsistence role and its socio-cultural functions are of paramount importance (Hanse and Jahnke, 1984). They are a means of hoarding for the thousands of breeders and a resource that can be quickly mobilized in case of urgent needs (diseases, bereavement, payment of tuition fees) (Pamo et al., 2004). However, it remains punctuated by a severe alternation between a period of crop biomass production limited to three or four months and a dry season that herds end in a situation of marked energy and protein deficit (CIRAD, 1992). Thus, the improvement of animal production depends not only on the genetic improvement and control of the health of livestock, but also for many of the animal feed.

To this end, the alleviation of seasonal deficits through a supply of quality complementary food and fodder is necessary especially in the dry season in the tropical zone.

> *Forage crops are intended to provide feed and the crops are distributed in kind or after dry storage or silage (Pagot 1985). The latter allow the breeder to manage the feed inputs of his livestock; the introduction of crops into the forage system is organized according to the objectives of raising, improving the performance of the herd and the conduct of all crops. Thus, in a rational system of fodder production imposed by the intensification of livestock currently occurring in some tropical countries and which is expected to develop, the stockpiling of a significant fraction of the plant material produced, is a pressing need.*

Since grassland production is seasonal, annual forages do not cover the critical periods (long dry seasons) that characterize these countries, the use of fodder in livestock feed can therefore be very important especially during the dry season. Among the tropical forages that can be conserved, there is the *Pennisetum Sp* which is one of the grasses which is of obvious interest from the zootechnical point of view because it makes it possible to fill the marked energy and protein deficits which characterize the tropical pastures during the dry season. It is within this framework that our study aims to evaluate the nutritional profile of "*maralfalfa"* hay *Pennisetum sp* associated with molasses for the evaluation of their physicochemical parameters.

MATERIALS AND METHODS

Study Area: The green forage harvest of «*maralfalfa*» was carried out in the experimental plots developed by the ACCEPT project (Adapting access to agro-pastoral resources in a context of Mobility and Climate Change for Pastoral Livestock in Chad) at the Institute for Breeding Research for Development (IRED). The analyses were carried out at the IRED Bromatology Laboratory and the CECOQDA (Food Quality Control Centre) physicochemistry laboratory.

Data collection: The green "*maralfalfa*" forage previously harvested in the experimental plots at the IRED was dried in the open air for 5 days and then cut into small pieces which will then be crushed in powder form with a grind. Chemical analyses of this forage were determined by methods accepted by the Association of Official Analytical Chemists (AOAC 1995). In this study, parameters such as organic matter (OM), dry matter (DM), moisture content, ash content, carbohydrates, fat, Raw fibre and protein were evaluated to determine the nutritional value of "*maralfalfa*" forage.

METHODS

Determination of the Chemical Composition of Rations

Determination of dry matter: The percentage of dry matter (DM) was determined by drying the "*maralfalfa"* and molasses samples in an oven at 105°C overnight. Crucibles, previously dried at 105°C overnight in a DRY-LINE oven, were cooled in a desiccator and weighed with a 104g precision electronic scale. 0.5g of the sample was fed into each crucible and then placed in the oven at 103°c overnight. The unit (crucibles + samples) was then cooled in a desiccator and weighed again.

The percentage of dry matter was calculated using the following formula:

DM = Dry Weight – Empty Crucible

Determination of organic matter

The organic matter (OM) was determined by subtracting the ashes from the dry matter (DM) according to the following formula:

OM (%MS) = 100MS - C

Where C = Ashes
DM = Dry matter

Determination of mineral matter

Principle: Mineral matter isobtained after destruction of the organic matter by incineration. This determination may be a prerequisite for further analysis (individual minerals, hydrochloric insoluble).

Operating mode: Put in a desiccator nickel crucibles previously dried in the oven for at least 1 hour. Do not put too many crucibles in the desiccator, maximum two rows.

After cooling, tare at 0.1 mg near each crucible. That is M0 their mass. Weigh in the crucibles, to the nearest 0.1 mg, about 3 g of ground sample. Let PE test sample. Spread the test sample evenly by a slight rotating motion. Put the full crucibles in the muffle oven. Turn on the extractor hood. Calcine for 4 hours at 550°C. Start the stopwatch as soon as the oven reaches the desired temperature. The time elapsed, wait until the oven temperature drops to 100°C, then take out the crucibles and let them cool in a desiccator. After cooling, weigh the crucibles to the nearest 0.1 mg. That is M1 of the mass.

Calculation

$$\%MM = \frac{M_1 - M_0}{PE} \text{ x } 100$$

Where:
MM: the mineral content expressed as a percentage of the gross product
M0: the mass in grams of the empty crucible
M1: mass in grams of the crucible containing the ashes

Determination of raw cellulose

Principle: Crude cellulose is by convention the organic matter that remains insoluble after acid and alkaline treatment. After any crushing and degreasing, the product is boiled by a solution of sulphuric acid of a specified concentration. Then separation and washing of the insoluble. Boiling treatment of the insoluble obtained by a solution of potassium hydroxide. Then separation, washing, drying, weighing of the insoluble residue and determination of its mass loss by incineration

Operating mode: 1g of the sample was weighed and then crushed to 1mm is supposed to contain more than 2% of crude cellulose in the filter crucible. In a 1-liter flask containing about 500ml of water, 7.22ml of concentrated sulfuric acid with water was added and adjusted after cooling. The concentration by titration with 0;1N NaOH was checked. Then 15.2g of KOH is introduced to be dissolved and completed with water. The crucibles containing the sample were placed in the fiber extractor, then 150 ml of previously heated sulfuric acid solution is added to each crucible and a few drops of octanol. The heating is turned on to the maximum, to be quickly brought to the boil (in about 5 minutes) and to maintain it for 30 minutes. After the boiling time, the heating is turned off and the insoluble is filtered immediately and completely. The valves were enclosed one by one, then 150 ml of hot water was poured into each crucible and filtered. This operation was repeated 2 to 3 times. After this series of handling, the crucibles were placed in a muffle oven at 550 °C for 4 hours, then let cool in the desiccator and weigh to the nearest 0.1 mg or M2 their mass.

$$\%\, CBW = \frac{(M1 - M2)}{PE} x\, 100$$

Where:
PE= test sample mass in grams;
M1= total mass of dry residue and the crucible before incineration;
M2= total mass of dry residue and crucibleafterincineration.

Determination of moisture content

Principle: The moisture content is generally determined by a thermogravimetric approach, that is by loss at desiccation. In this case, the sample is heated and the weight loss due to moisture evaporation is recorded. This process is traditionally carried out in a drying oven with a scale to determine the initial and final weight of the sample, then using a formula to determine the moisture content (sample weight + empty crucible – sample dry weight / sample collection). This process typically takes several hours (24 hours) to

complete. The moisture content was determined using the following formula:

$$\%\ humidity\ =\ \frac{PE\ +\ cv\ -\ cms}{PE}\ x\ 100$$

Where: PE= sample weight;
CV= empty crucible;
CMS= dry weight of the sample

Determination of ash content: The ash was determined by incineration of the samples in a muffle oven for 8 hours. After numbering the various crucibles, they were placed in the oven for 30 minutes at a T of 105C. at the exit the crucibles were put in a desiccator for cooling to room temperature and then place one by one on the scale and note the weight (the scale was tared at each weighing). 5g of the dry matter (Sample) to be analysed was weighed in the crucible. The sample was placed in the "Nabertherm" brand muffle oven for 8 hours at a T of 550°C, with a preheat time of 3 hours. at the outlet the crucibles containing the incinerated sample are placed in the desiccator for a few minutes to be cooled and repainted. The ash content (percentage of ash to dry matter) was determined using the following formula:

$$\%\ Ashes\ =\ \frac{pc\ -\ cv}{Ms}\ x\ 100$$

Where: pc= ash weight
cv= empty crucible;
Ms= dry matter

Determination of Crude Proteins (KJELDHAL): The nitrogen content was determined by the Kjeldhal method, which successively includes mineralization, distillation and titration.

Principle: The determination of crude proteins is based on the transformation of organic nitrogen into ammonia nitrogen by mineralization with concentrated sulfuric acid. Concentrated sulphuric acid destroys proteins in organic matter by oxidation and binds the amine group of the protein according to the following equation:

$$\underset{\text{organic matter}}{MO + H_2SO_4} \xrightarrow[\Delta]{\text{catalyst}} (NH_4)_2SO_4 + \underset{\text{ammonium sulfate (pale green)}}{R\text{-}CH_2\text{-}COOH}$$

By distillation, the ammonium hydroxide dissociates and vaporizes, and is then liquefied in the coolant. The ammonia thus released is collected in boric acid (40%) then determined by acid titrimetry base according to the following equations:

$$\underset{\text{(Pink)}}{NH_3 + H_3BO_3 + H_2O} \longrightarrow NH_4H_2BO_4\ \text{(Green coloured borate)}$$

$$\underset{\text{(Green)}}{NH_4H_2BO_3} + \underset{\text{(acid)}}{XH} \longrightarrow H_3BO_3 + NH_4X\ \text{(pink colour)}$$

Operating mode: Two test portions of each sample (*maralfalfa* and molasses) are introduced into a matrass numbered from 1 to 4 and a white matrass, into which were poured 15g of (K2SO4), 0.6g of (CUSO4), 2Oml of (H2SO4); 70ml of (NaOH), 50ml of (H3BO3), 5 pumice stones, 5 drops of defoamer, 10 drops per sample of bromocresol green and 4 drops per sample of methyl red. The whole was introduced into a mineralization flask (in Pyrex) with 10 ml of concentrated sulfuric acid, and brought to high temperature on a mineralization ramp. After 3 hours of mineralization, a light green solution reflecting the conversion of organic nitrogen to ammonium sulphate was obtained. The flask was cooled and its contents transferred to a 100 ml volumetric flask and the volume was adjusted to the gauge line with distilled water. 10 ml of each mineralized solution were taken and fed into the distillation tube. The assembly was then mounted on the Kjeldhal distiller, and 20 ml of NaOH (40%) was added. The end of the distillator coolant was immersed in 20 ml of the mixture of boric acid (40%) and coloured indicators (bromocresol green and methyl red) contained in a 250 ml Erlenmeyer. During distillation, the ammonium hydroxide dissociates, vaporizes, is liquefied in the refrigerant and then recovered in boric acid that turns red to green.

At the end of the distillation, 150 ml of distillate was recovered and titrated in the presence of HCl.

The nitrogen (N) content was then calculated using the following formula:

$$WN_1 = \frac{(1{,}4007)\ x\ (V1 - V0)\ x\ (0{,}1)}{mPE}$$

Where V= Volume of HCL used for sample titration
V0= Volume of HCL used for white titration,
mPE= Weight of the mineralized sample.

$$WN_2 = \frac{(1{,}4007)\ x\ (V1 - V0)\ x\ (0{,}1)}{mPE}$$

Where V= Volume of HCL used for sample titration
V0= Volume of HCL used for white titration,
mPE= Weight of the mineralized sample.

$$\text{Average Nitrogen Levels} : \frac{(WN1 + WN2)}{2}$$

The crude protein content (BP) was obtained by multiplying the nitrogen content by the coefficient 6.25.

Determination of Butterfat

Principle: The lipid content is determined by the Soxhlet method. This method is based on lipid solubilization in apolar organic solvents.

Operating mode: In the soxhlet extractor (100 ml), a cellulose cartridge containing 1g of Pennisetum Sp "maralfalfa" sample was inserted, which had been previously wrapped in aluminium foil and in another soxlet 1g of molasses sample extractor. The assembly was then fixed on a refrigerant mounted on a previously weighed flask (250 ml). At the end of the extraction, after evaporation of the solvent, the flask was placed in a «DRY-LINE» brand oven at 100oC for one night. At the exit, it was cooled in a desiccator and weighed (pf). The lipid content of the sample was determined using the following equation:

Lipids (% MS) = ((Pf – P_0)/m_0) x *100* Where:

Determination of total carbohydrate levels

***Principle*:** The principle consists in hydrolyzing the polysaccharides of the sample by inversion in order to have reducing sugars that then go, in the presence of Fehling liqueur (Bertrand dosage that reduces copper).

Operating mode

Total reversal of carbohydrates: 4g of each sample (maralfalfa and molasses) were weighed in two different balloons, then 40ml of

distilled water, 1ml of zinc acetate and 1ml of chloridric acid are added to the test portion. The refrigerant was adapted to the flask and connected to the tap hose. The mixture is brought to a boil for 2 hours 30 minutes with reflux heating. After cooling, 3 drops of phenolphthalein were added, followed by 15ml of NaOH. Everything is poured into a 1000ml flask taking care to rinse the flask to recover all the residue and about 20ml of warm water was added before the gauge line. 2 ml of NaOH was added until the solution was neutralized (or slightly acidic) and then supplemented with warm water up to the gauge line and filtered.

Dosage by the Bertrand method: 20ml of the alkaline solution, 20ml of the copper sulphate solution and 20ml of the sample solution were transferred to a test tube, then heated until boiling and kept boiling for 3minutes, then cooled and centrifuged. In an Erlenmeyer, the supernatant solution was poured while being careful not to lose the oxide formed.

The total carbohydrate content of the sample was determined using the following equation:

$$G = \frac{S \, x \, 100}{m \, x \, v0}$$

Where :
S: Cu's correspondence in invert sugars according to the fehling table
G: total carbohydrate content (%)
m: test portion (g)
V0: the volume taken for the (20ml) assay

Determination of fiber content

Operating mode: Sample collection "*maralfalfa*" was ground to a fairly large grain (1mm mesh sieve) and the reagents were heated on the hot plate to 95–1000C. These samples were put in the crucibles and placed in their «crucible support rack». This rack has been attached to the front of the main unit. Using the rack with handle, the crucibles were placed in the main unit facing the heating resistors and the fixing lever was lowered as well as the reflector screen. All valve controls are in the closed position and the chiller tap is open with a flow rate of 1 to 2 liters per minute.

Hot extraction process: The top lid was lifted and in each column the reagent was poured, the necessary quantity was determined by the graduation of each column. The knob of the adjustment potentiometer has been rotated clockwise to the 80 -90% position and the heater resistor is turned on. When the reagent begins to boil, the power of the heater is reduced while bringing the potentiometer knob counterclockwise up to 20 - 30%. At the end of the extraction time, the heater was switched off by the switch, then the water pump suction valve was opened and the valve control buttons were put in the "aspirate" position. At the end of filtration, the valves are closed. Hot distilled water was used to wash the samples while using a sprayer, water is introduced at the inlet of each column. The valve controls are in the "aspirate" position to keep the samples dry. The "rack-holder with handle" was used to remove the crucibles from the extraction unit.

RESULTS AND DISCUSSION

RESULTS

These results concern the physico-chemical analysis of "*maralfalfa*" fodder and molasses. The latter present measured and calculated values. The measured values give the chemical composition of a forage; they are determined by chemical analysis. From the chemical composition and according to the characteristics of the forage (nature, species, vegetation cycle), equations allow to calculate the feeding values for the animal species in question. Table I below summarizes the results of the different dosed parameters of *Pennisetum sp* hay (*maralfalfa*) and molasses.

Table 1. Chemical composition of *Pennesitum sp* hay (*maralfalfa*)

Chemical composition	*Maralfalfa* hay
Dry matter (%)	4.56
Organic matter (%)	31.70
Mineral matter (%)	14.17
Raw cellulose (%)	35.7
Moisture content (%)	8.66
Ash rate(%)	36.66
Crude proteins (g)	8.39
Fat (%)	2.68
Carbohydrates (g)	23.13
Fiber content (%)	36.29
Standard deviation	14.02

Table 1 presents the chemical composition results for Pennisetum sp "*maralfalfa*" hay. From this table, we note that the levels of fiber, total carbohydrates (TC), ash, crude proteins (CP), raw cellulose (RC) have the highest values. Moreover, the lowest values were obtained with lipid levels and dry matter.

Table 2. Chemical composition of Pennicillar millet bran

Chemical composition	**Pennicillar millet bran**
Dry matter (%)	100
Organic matter (%)	
Mineral matter (%)	2.80
Raw cellulose (%)	3.20
Moisture content (%)	
Ash rate(%)	0.60
Crude proteins(g)	6.70
Fat (%)	4.80
Carbohydrates(g)	63.20
Fiber content (%)	9.70
Standard deviation	37,06

Table 3 shows the chemical composition of pennicillary millet bran (small millet). The table shows that the dry matter (DM), crude protein (BP), total carbohydrate (TC) and fiber content have the highest values according to the determination of these different parameters as indicated in the table above.

Table 3. Chemical composition of sugar cane molasses

Chemical composition	Sugar cane molasses
Dry matter	72.3
Organic matter	x
Mineral matter	10.3
Raw cellulose	0
Moisture content	47.44
Ash rate	0.2
Crude proteins	4.2
Fat	1.4
Carbohydrates	73
Fiber content	0
Standard deviation	26,80

The table shows that the levels of crude protein (BP), mineral matter (MM) and total carbohydrates (TC) are the highest among the parameters studied. On the other hand, the contents of fibres and raw cellulose are zero.

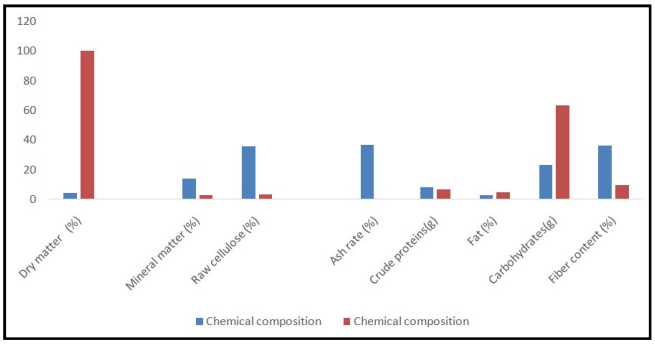

Figure 1. Chemical composition of "*maralfalfa*" hay and pennicillar millet bran

The Figure I shows the chemical composition of "*maralfalfa"* hay and pennicillar millet bran in comparison. This figure shows that "*maralfalfa"* hay has a higher fibre content than millet-pennicillar bran and a slightly higher protein content than millet-pennicillar bran. This means that "*maralfalfa"* is an energy source.

DISCUSSION

In order to cover the maintenance needs of the animals and hope for a minimum of production of small ruminants especially during the dry season, it is important to improve the nutritional value and the appetite of certain forages such as *Pennisetum sp* (*maralfalfa*). The assessment of the chemical composition of the *Pennisetum sp (maralfalfa*) forages used to formulate the feed ration provides information on the nutritional value of the feed ration. Better still, this determination of the chemical composition of food rations serves to confirm the effectiveness of nutritional values in meeting the nutritional requirements of these small ruminants.The values of the chemical composition of *maralfalfa* hay determined in this study to formulate an experimental ration are quite close to those obtained by bromatological analysis of the green fodder of *Penisetum maximum and Pennisetum* purpureum determined by M.k. Ettian et al in 2016, This is because these forages belong to the same family of grass forages (poaceae). On the other hand, the rates of dry matter and fibre are lower than those obtained by the same author. As well as the rate of dry matter, fibres, ash, crude cellulose; fats obtained in other studies carried out by Fantodji and Soro, 2004; Traoré et al 2008 are higher than that of our study.The fat content, which is rich in energy elements, is the lowest of the parameters studied, as shown in Table 1.

As for fibres, their rates are quite high and their transformation is an important source of calories, as confirmed by the work of several authors on the energy intake of fiber-rich foods consumed (Van Zyl et al., 1999; Jokthan et al., 2006; Karikari and Nyameasem, 2009; Van Zyl and Delport, 2010; Etim et al., 2014). However, forage grasses contain many physico-chemical compositions when consumed rationally by livestock. This assertion corroborates those of other authors such as Kouakou et al., 2010, Ramirez-Riviera et al., 2010, Traoré et al., 2009 and Traoré, 2010. This suggests that *Pennisetum sp* being also a grass, could have a similar effect on animals. The results of this study show that the chemical nutrient composition of *Pennisetum sp* "*maralfalfa*" is mainly favorable to a basic diet for farm animals. This can be explained by the fact that stems from stalk forage grasses are succulent and sweet-tasting and easily digested. This study has shown that *Pennisetum sp* has a high nutritional and energy quality and can be popularized in livestock. Molasses is the crystallized sugar obtained after the cooking of the cane juice during the manufacture of the sugar in the factories. It contains about 25% water. It is a highly energetic food containing crystallized sucrose (30% of the dry matter), reducing sugars (25% of the dry matter) and other carbohydrate substances (INRA, 1988). Molasses is used in ruminant feeding in combination with coarse forages such as cereal culms, straws or other cellulosic (bran) foods, and is a rapidly fermentable energy source in the form of ATP (Chenost and Kayouli, 1997). It acts as a binding agent in rations or to promote the ingestion of less appetizing foods (hay, straws, stubble). Molasses is very appetized thanks to its sugars and mineral salts (Bernard et al., 1991; Rivière, 1991).

The maximum desired intake of molasses is 4-5% in ruminant feed to improve the ingestion and digestibility of coarse forage during the dry season (Rivière 1991). Indeed, in this study, the DM content of the molasses and the carbohydrate found are lower than those obtained by Christon and Le Dividich in 1978, however, the protein level obtained in this study is much higher than that obtained by the same author. According to H. Archimède et al in 2011, this difference in chemical composition is due to the location where the plant material (sugar cane) was harvested, and the molasses available in Guadeloupe and Martinique is the least rich in sugar. According to the same author, this difference is related to the progressive extraction of sugar during the molasses manufacturing process.

CONCLUSION

At the end of this study, analysing the chemical composition of "*maralfalfa*" hay *Pennisetum sp* and molasses, it emerges that these latter could constitute the base in feeding of livestock. The nutritional value and appetite of "*maralfalfa"* fodder combined with molasses would improve the nutritional needs of the animals. In perspective, it would be desirable to popularize pastoral resources such as "*maralfalfa*" *Pennisetum sp*, forage grass that is rich in protein, water, fiber and cellulose to be used in small ruminant farming. In addition, this work could continue by studying the in vivo appetite and digestibility of "*maralfalfa*" hay associated with molasses in small ruminants in maintenance and production.

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