Nutritional value of ensiled *Guizotia abyssinica* (Noug: Niger) treated with salt, molasses, urea or barley (#109956)

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Nutritional value of ensiled *Guizotia abyssinica* (Noug: Niger) treated with salt, molasses, urea or barley

Ayşe Gül Filik Corresp. [1]

[1] Agricultural Biotechnology /Agricultural Faculty, KAEU, Kırşehir, Turkey

Corresponding Author: Ayşe Gül Filik
Email address: aysegulcivaner@ahievran.edu.tr

The research aimed to assess the nutritional value of ensiled *Guizotia abyssinica*, also known as Noug: Niger, treated with various substances such as urea, salt, molasses, and barley. The eight experimental groups were as follows: (I) Niger forage without any supplementation as a control; (II) with supplement of 1% salt; (III) with supplement of 2.5% molasses; (IV) with supplement of 2.5% urea; (V) with supplement of 5% barley; (VI) with supplement 2.5% molasses and 1% salt; (VII) with supplement 2.5% urea and 1% salt; and (VIII) with supplement of 5% barley ad 1% salt. Silage samples were analyzed through physical, chemical, and microbiological means in order to determine their nutritional content, sensory qualities, and detectable microorganisms. The aim of this analysis was to provide an objective evaluation of the silage samples. Based on the evaluation of relative feed value (RFV) and relative forage quality (RFQ), it was determined that Niger forage with 2.5% urea produced the highest quality silage. In conclusion, the Niger plant displays potential as a high-quality silage. It is recommended to silage Niger forage with varied additives and rates. Further investigations are required to establish its in vitro digestibility and animal preference in vivo.

Full Title:

Nutritional value of ensiled *Guizotia abyssinica* (Noug: Niger) treated with salt, molasses, urea or barley

Abbreviate Title:

Noug silage with salt, molasses, urea or barley

Ayşe Gül FİLİK[¥1]

Correspondence Author: aysegulcivaner@ahievran.edu.tr

[¥] Kırşehir Ahi Evran University, Agriculture Faculty, Agricultural Biotechnology Department, Bağbaşı Mah. Şehit Necdet Yağız Bul. No: 143/E 40100
Merkez-Kırşehir/Türkiye
Mobile Phone: 00905056893911
Office Phone: 00903862804835
Fax: 00903862804832
Orcid Number: https://orcid.org/0000-0001-7498-328X

HIGHLIGHTS

- To enhance the nutritional value of Niger silage.
- To produce Niger silage with different additives.
- To demonstrate the potential of an alternative silage for ruminants.
- The feasibility of silaging Niger was established for the first time.

Abstract

The research aimed to assess the nutritional value of ensiled *Guizotia abyssinica*, also known as Noug: Niger, treated with various substances such as urea, salt, molasses, and barley. The eight experimental groups were as follows: (I) Niger forage without any supplementation as a control; (II) with supplement of 1% salt; (III) with supplement of 2.5% molasses; (IV) with supplement of 2.5% urea; (V) with supplement of 5% barley; (VI) with supplement 2.5% molasses and 1% salt; (VII) with supplement 2.5% urea and 1% salt; and (VIII) with supplement of 5% barley ad 1% salt. Silage samples were analyzed through physical, chemical, and microbiological means in order to determine their nutritional content, sensory qualities, and detectable microorganisms. The aim of this analysis was to provide an objective evaluation of the silage samples. Based on the evaluation of relative feed value (RFV) and relative forage quality (RFQ), it was determined that Niger forage with 2.5% urea produced the highest quality silage. In conclusion, the

[1] **Corresponding Author:** Ayşe Gül FİLİK, https://orcid.org/0000-0001-7498-328X
Kırşehir Ahi Evran University, Agriculture Faculty, Agricultural Biotechnology Department, Bağbaşı Mah. Şehit Necdet Yağız Bul. No: 143/E 40100, Merkez-Kırşehir/Türkiye
Mobile Phone: 00905056893911 Office Phone: 00903862804835 Fax: 00903862804832

Niger plant displays potential as a high-quality silage. It is recommended to silage Niger forage with varied additives and rates. Further investigations are required to establish its in vitro digestibility and animal preference in vivo.

Keywords: *Niger*, relative feed value, relative feed quality, silage additives, sustainability

Introduction

Silage is the primary or most frequently used feed source in ruminant nutrition. Maize crops usually come to mind when discussing silage. Nonetheless, growing maize for silage necessitates a water supply of 400-750 mm during the growing season (Kuşvuran et al. 2015). Droughts resulting from climate change worldwide have boosted water demand recently, prompting countries to make critical decisions about changed agricultural models and policies. Meeting these decisions necessitates expanding production of crops replete with yield characteristics and content yet having low water requirements whilst being cultivated. With the rapid growth of the population and the conversion of agricultural land for urbanization, there is an overlap in the land requirements of human and animal feed crops. To address this issue, researchers have redirected their focus towards producing crops that can thrive on marginal, arid or poorly irrigated land, as opposed to traditional cereals or forage crops that are used on fertile land (Degu et al. 2009; Filik and Filik, 2021a). In recent years, the FAO has added traditional crops to its drought management agenda that are capable of fulfilling the high nutrient requirements of humans and animals in arid regions. (Filik, 2020). This includes alternative plants in the pseudo-cereal group, such as amaranth, chia, finger millet, common buckwheat, quinoa, and teff (FAO, 2019), all of which have been identified as potential sources of sustenance. In addition to these crops, there is Niger (*Guizotia abyssinica*), which has gained significance beyond Ethiopia and India in recent years. It thrives particularly well in poorly ventilated and unfavorable soils (Alemaw and Wold, 1992; Alemayehu and Ashagrie 1992). Although some sources suggest that it was domesticated around 3000 BC (Hiremath and Murthy, 1988), archaeobotanical evidence indicates that it was first used between 800 BC and 700 AD during the Aksumeti period (Boardman, 1999, 2000). This plant is an annual dicotyledonous species with excellent biomass potential for fuel, capable of reaching up to 2m in height, yielding 340 kg of seeds per hectare, and having a rich oil content of around 40%, notably in its seeds (Getinet and Sharma, 1996; Gordin et al., 2015). The oil obtained has a light-yellow hue, a pleasant aroma and a hazelnut-like flavor profile. Chemical analysis indicates that it comprises 75.4% linoleic acid, 9.7% palmitic acid, 6.9% stearic acid, 7.0% oleic acid and less than 0.1% linolenic acid (Alemaw and Wold, 1992; 1995). Niger seed is utilized for human consumption due to its nutritional benefits and also for its high oil content. The cake that is left behind once the oil has been extracted is utilized as a source of protein in animal feed for fish, monogastric animals (such as laying hens, broilers, and pigs) and ruminants (calves of cattle, oxen, goats, sheep, and camels) (Merrea et al. 2004; Duguma et al. 2004; Dekebo et al. 2004; Dessalegn et al. 2004; Galmessa et al.2004). 2004; Bekele et al. 2004; Asfaw et al. 2004; Alemu et al. 2010; Asmare et al. 2010; Kitaw et al. 2010; Alem et al. 2011; Tadesse et al. 2012; Nurfeta et al, 2013; Kebede and Tadesse 2014; Chibsa et al. 2014; Abraham et al. 2015; Diba et al. 2015; Melesse et al. 2015; Abebe et al. 2017; Ayenew et al. 2019; Abreha et al. 2019; Adugna et al. 2019; Bahadır Koca et al. 2019; Ali et al. 2020; Mengistu et al. 2020). Ruminant feed can comprise up to 49.5% Niger seed meal (Duguma et al., 2004; Dessalegn et al., 2004; Merrea et al., 2004; Mekonnen et al., 2019). Niger is cultivated for both its seeds and oil, and its cake is becoming an increasingly vital source of crude protein for animal nutrition after oil extraction. However, in general, its use has been neglected and underutilized in scientific studies within the scientific community, particularly in relation to green herbage yield or silage (Getinet & Sharma, 1996). As a result, the findings of this study have the potential to be pioneering, attracting the attention of numerous researchers whilst possessing distinct literary qualities, making it truly unique in the field. Furthermore, the study results were compared to the sunflower plant, which is the Niger plant's closest genetic relative (Dempewolf et al. 2010) and also utilized as animal nutrition silage.

Materials and Methods

The study was carried out in the agricultural experimental field area at Kırşehir Ahi Evran University in Türkiye. The research site is located at a longitude of 39°10´N and 34°22´E and at an altitude of 988 m above sea level. The cultivation of the Niger plant occurred between May and September 2016. The monthly precipitation and temperature averaged from 0 to 98 mm and 8.1 to 34.68°C, respectively. The seeds of *Guizotia abyssinica* (also known as Noug or Niger) were acquired from the Bahri Dağdaş International Agricultural Research Institute, the Ministry of Agriculture and Forestry in the Republic of Türkiye. The method of Peiretti et al. (2015) was used to cultivate the seeds and evaluate the nutrient levels of the Niger plant at various stages. During the early flowering period, the Niger plants were chopped using knives and cut into appropriate sizes for producing silage. The chopped plants were mixed uniformly with additives such as urea, salt, molasses, and barley. Subsequently, the mixtures were weighed and replicated four times. In totality, 32 silage samples were prepared and stored in bags measuring 200×250 mm with an oxygen permeability rate of 1.13 cc/m^2 day. Vacuum sealing of the samples was done using a laboratory-grade Packtech PT-VKM-CPRO machine. Treatment groups were prepared, consisting of the Control group and groups treated with various combinations of Niger, Molasses, Salt, Urea, and Barley as follows: Niger with 1% Salt, Niger with 2.5% Molasses, Niger with 2.5% Urea, Niger with 5% Barley, Niger with 2.5% Molasses and 1% Salt, Niger with 2.5% Urea and 1% Salt, and Niger with 1% Salt and 5% Barley. Silages that had been prepared were placed under scrutiny at the Enzyme and Microbial Biotechnology Laboratory, located within the Department of Agricultural Biotechnology at the Faculty of Agriculture in Kırşehir Ahi Evran University. The temperature was maintained at 20±2 °C. On the 90th day, the temperature was measured using a LYK 9263 digital thermometer, pH was measured with an Eutech Instruments pH 700, water-soluble carbohydrates were measured using a Hanna Instruments HI 96801 Digital Refractometer with Brix degree ranging from 0 to 25°, and color was assessed via a Konica-Minolta CR-410 color meter, as referenced by Magalhães et al. (2012a; b), Filik et al. (2018), Çayıroğlu et al. (2020), and Filik and Filik (2021a). The Fleig Score (FS) was also measured. The quality of silages was assessed by calculating the DM and pH values in accordance with the formula outlined by Kılıç (1986).

$$FS = 220 + (2 \times DM\% - 15) - 40 \times pH$$

Silages scoring between 100 and 80 on the Fleig scale are regarded as excellent, while those between 80 and 61 are considered good, and those ranging from 60 to 41 are considered average in quality. Silage scoring between 40 and 21 is deemed of low quality, and silage with scores ranging from 20 to 0 is considered very poor (Kılıç, 1986). After conducting physical property assessments, the silage samples underwent drying in a ventilated BINDER ED115 oven at 65°C for 48 hours. Upon completion of the drying process, analysis for air dry matter was carried out. The dried samples were then ground, passing through a 1 mm sieve using the Ultra-Centrifugal Mill ZM 200- Retsch (Filik and Filik, 2021b). Dry matter (DM) was determined using the 925.40 method, while organic matter (OM) was measured using the 934.01 method. Crude protein (CP) was measured with the 984.13 method, ether extract (EE) with the 920.39 method, and ash was determined using the ash method 942.05 (4.1.10). AOAC procedures (2006) were employed for all determinations. Crude cellulose (CF), acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL) were analyzed using the Ankom200 Fiber Analyzer by Ankom Technology Corp., located in Macedon, NY, USA, in accordance with the procedures outlined by Van Soest et al. (1991) and Ankom (2016; 2017a; 2017b; 2017c). Total Carbohydrate (TC) content, Non-Fiber Carbohydrate (NFC), and Nitrogen-Free Extract (NFE) content (g/kg) were analyzed following AOAC procedures (2006). The procedures used were TC method BFM156 and NFC method BFM121. Total digestible nutrient (TDN%) values, Digestible energy (DE Mcal/kg), Metabolizable energy (ME Mcal/kg), Net energy-lactation (NEL Mcal/kg), Net energy-maintenance (NEm Mcal/kg) and Net energy-gain (NEg Mcal/kg) values were calculated using silage nutrient analysis results (Moe et al. 1972; Heeney, 1978; Garrett, 1980; NRC, 2001; Schroeder, 2004). Dry matter intake (DMI), digestible dry matter (DDM), relative feed value (RFV), and relative forage quality (RFQ) were calculated using acid detergent fibre (ADF), neutral detergent fibre (NDF), and total digestible nutrients (TDN) data (Rohweder et al., 1978; Linn and Martin, 1991; Undersander and Moore, 2002; Undersander, 2003; Kiliç and Abdiwali, 2016). Total live bacterial (TLBc) and lactic acid bacteria count (LABc) were determined according to the methodology described by Harrigan (1998). Microorganism counts were done by plate counting, following the procedure outlined by Cai et al. (1999). The mean of the chemical quality values was determined using four separate data points. Protein values and metabolizable energy were calculated from the chemical analysis results corrected on a dry matter basis. The RFV and RFQ were also determined based on the chemical analysis results. Descriptive statistics were analyzed using Descriptive Variables for the statistical analysis of the data. The SAS (SAS Institute, 2001) statistical software package was used to compute the Standard Error of Difference (SED), as well as the Duncan multiple range test (Genç and Soysal, 2018). To test for linear, quadratic, and cubic effects resulting from Niger silage groups, single-degree-of-freedom polynomial contrasts were also employed (Steel and Torrie, 1980).

Results and Discussions

There have been many studies on the evaluation of the Niger cake, after extraction of the rich oil, in terms of animal nutrition. Chavan (1961) reported that silage from the Niger plant cannot be used in cattle feeding but can be fed to sheep. Except for the study of Peiretti et al. (2015) on the evaluation of Niger plant as roughage in terms of animal nutrition in different vegetation periods, there is no reference on its roughage or silage potential. The present study will be the only reference study on the silage ability of Niger plant harvested during the early flowering period with the addition of urea, salt, molasses, or barley additives.

The most important parameter during silage fermentation is the pH of the silage. In the current study, as given in Table I, silage pH was respectively Control (Niger), Niger with 1% Salt, Niger with 2.5% Molasses, Niger with 2.5% Urea, Niger with 5% Barley, Niger with 2.5% Molasses + 1%. Salt, Niger with 2.5% Urea + 1% Salt, and Niger with 5% Barley + 1% Salt groups were determined as 4.39, 4.38, 4.20, 4.21, 4.40, 4.13, 4.06, and 4.18. The quality of fermentation in silage is determined by calculating the Flieg score and the most effective parameter is pH. A high DM content of the silage material can negatively affect silage quality by reducing acidity and preventing LABc formation (Gürsoy et al. 2023). The pH of quality silage should be between 3.70 and 4.20 (Kung and Shaver 2001). Another parameter that is important in silage quality is WSC, which was determined in the study as 15.50, 15.25, 15.75, 16.75, 16.00, 18.25, 18.50, and 15.50, respectively. In addition to pH, DM content, WSC content and Flieg score of the silage are important parameters for silage quality and the differences among the groups in the mentioned characteristics were found to be statistically significant in the present study. The pH decreased in the treatment groups compared to the control group and the decrease was realized in a way that positively affected the silage quality. As can be seen from the Flieg scores, the treatments had an increasing effect on the quality of the silages considering pH, DM content, WSC content and Flieg scores, the best silage groups were Niger with 2.5% urea and 1% salt, and Niger with 2.5% molasses and 1% salt. The addition of 1% salt disturbed the osmotic pressure in Niger and caused an increase in WSC content. There was an increase in silage pH with increasing WSC content and the desired pH range for quality silage was achieved. In addition, urea and molasses in the silage were a good source of energy for the lactic acid bacteria to continue their vital activities. Within these two groups, the best LABc growth was achieved in the group with urea added, and the energy required for the vital activities of the bacteria was provided by WSC, while nitrogen was supplied by urea. On the contrary, in the molasses added group, the high WSC content and the high energy availability due to the addition of molasses as an energy source provided an environment for the growth of LABc and other bacteria. As expected, the highest WSC content was found in the silage of Niger with 2.5% urea + 1% salt. The silages of Niger with 2.5% molasses + 1% salt, Niger with 2.5% urea and Niger with 5% barley showed WSC content values being not significantly different from the silage of Niger with 2.5% urea + 1% salt. Kılıç (1986) evaluated Fleig scores between 80-100 as very good, 61-80 as good, 41-60 as fair, 21-40 as poor and 0-20 as very poor silage quality. According to Fleig scores, 2.5% molasses + 1% salt with Niger and 2.5% urea + 1% salt with Niger, 2.5% molasses with Niger, 5% barley + 1% salt with Niger, 2.5% urea with Niger were in the very good silage evaluation group, while 5% barley with Niger, 1% salt with Niger and control were in the good silage evaluation group ($P<0.0001$). According to the Fleig score, all additives had positive effects on the silages when comparing the control and treatment groups. The color values measured four times from the silage surface are expressed as L*: lightness (black: 0 - white: 100), a*: red to green (+a*: red, -a*: green) and b*: yellow to blue (+b*: yellow, -b*: blue). When the L*, a* and b* values of the silage were examined in the color values, it was found that the silage had a dark green color (Table I). While Çayıroğlu et al. (2020) found a medium dark color with increased yellowing in their study with sugar beet, Filik and Filik (2021a) reported that the color of Amaranths silages made with similar additives was a dark green silage, similar to the current study.

In Table II, where the nutrient contents of the silages are examined, the DM values were determined as 201.09, 217.20, 248.93, 231.43, 232.14, 268.01, 254.02, and 242.55, respectively, and the difference between the groups was found to be statistically significant ($P<0.01$). In the study where the effects of different sunflower populations, different harvest times and different additives on silage quality were investigated, the DM and NDF values of the control group were similar to those of the control group of our present study (Dumlu Gül and Tan, 2021). These results provide an opportunity to compare Niger with sunflower. In the present study, the addition of molasses further increased the energy requirement of the bacteria in the silage and enabled the bacteria to use crude oil, which is the other most readily available energy source, to meet their energy needs. In the groups to which urea was added (2.5% urea with Niger and 2.5% urea + 1% salt with Niger), the required energy was provided by ADF and NDF, which are structural carbohydrates, due to the lack of energy source, whereas in the group to which salt was added (2.5% urea + 1% salt with Niger), it was more evident that it was used for energy purposes due to the disruption of the cell structure by salt.

Table III, where the energy values of Niger silages prepared with different additives are given, all the energy value parameters were statistically affected ($P<0.01$).The NFC ($P<0.01$) and TC ($P<0.05$) values of the control group were positively influenced by the treatments, and Niger with the 5% barley + 1% salt group was the best in DE, ME, NEL, NEM and NEG values. The reason for this is that the addition of salt disrupted the cell structure of barley, which has an easily degradable carbon hydrate structure, and silage energy values increased with the release of carbohydrates.

The microbial growth is shown in Figure I. Niger with 2.5% urea + 1% salt had the lowest energy value and LABc showed the highest development in this group. The increase in LABc was caused by the addition of urea and salt to the silage. Urea provided the necessary N source for LABc growth and salt provided the necessary light energy by disrupting the cell structure and lowering the pH, thus preventing yeast and mould formation (Yunus et al. 2000). Canpolat et al. (2014) reported that urea added to pomegranate pulp silage prevented yeast and mould formation, reduced pH and improved LABc formation, in parallel with the results of our study.

As this is the first publication on Niger, RFV (relative feed value) and RFQ (relative feed quality) values were evaluated and presented in Table IV to determine how much plant silage can meet the needs of the animal at what times under in vitro conditions. In particular, RFV was calculated via ADF and NDF values to determine the energy and roughage requirements of the animal and to try to reveal the quality of the feed (Filik and Filik, 2021 a; b). The most important feed evaluation criteria, RFV shown in Table IV, were 127.44, 139.13, 135.21, 192.28, 152.52, 143.88, 161.62 and 145.23 ($P<0.01$). According to the RFV values, the control group was defined as quality III, the groups of Niger with 1% salt and Niger with 2.5% molasses + 1% salt were defined as quality II, Niger with 2.5% molasses, Niger with 5% barley + 1% salt, Niger with 5% barley, Niger with 2.5% urea + 1% salt and Niger with 2.5% urea were defined as the best quality. It was concluded that quality increased in the groups that provided energy and protein sources necessary for the continued fermentation of silage bacteria, and the best RFV value was observed in the silage of Niger with 2.5% urea.

Another important parameter is the RFQ parameter, which was developed for feeding according to animal performance using DMI, which calculates how much DM consumes the animal, and TDN values, which determine how much digestible nutrients receives the animal with the feed it consumes (Filik and Filik, 2021 a;b). Interpreting the results, the silages from Niger with 2.5% urea and Niger with 2.5% urea + 1% salt with seem to be of the best quality and are not recommended for use except for 18 to 24 months dry cows, while silages from Niger with 5% barley , Niger with 2.5% molasses + 1% salt and Nger with 5% barley + 1% salt for dairy, 1st trimester dairy calf, silages from control, Niger with 1% salt and Niger with 2.5% molasses for dairy, last 200 days heifers, 3 to 12 months stocker cattle.

This study is the only reference study examining the usability of Niger plant harvested during the early flowering period by adding urea, salt, molasses or barley additives to evaluate the quality of silage. By calculating the Flieg score in determining the quality of silage, the most effective parameter is determined as pH. High DM content of silage material can negatively affect silage quality by reducing acidity and preventing LABc formation. The pH value of quality silage should be between 3.70 and 4.20. In addition to pH, DM content, WSC content and Flieg score are important parameters for silage quality, and the differences between groups in these properties were found to be statistically significant. The addition of urea and molasses promoted the growth of LABc in silage and provided energy to maintain the vital activities of bacteria. Among these two groups, the best LABc growth was obtained in the group with urea added. High WSC content and energy amount in the molasses added group provided an environment for the growth of LABc and other bacteria. Since the pH value of the silage increased in the group where urea and salt were added, the desired pH range was reached in the silage. More energy requirements enable silage to be used by bacteria. In the groups to which urea was added, the required energy was provided by the structural carbohydrates ADF and NDF. The high LABc development observed in these groups increased because urea provided the N source necessary for LABc growth and salt prevented the formation of yeast and mold by disrupting the cell structure and lowering the pH. Addition of salt and molasses in Niger increased the energy values of silage.

As a result, RFV and RFQ values were examined to determine how much silage made with Niger plant could meet the needs of animals. Silages to which urea has been added have been found to be of the highest quality and should not be used except for dry cows aged 18-24 months. Other groups are recommended for different animals at different periods. It was concluded that Niger silage made with the addition of barley, salt, molasses, or urea, which are the basic silage additives, can be a suitable silage material under in vitro conditions. However, replication of the study in high-capacity silages and with different additives will be able to attract the attention of farmers as an alternative silage crop, especially today when the global climate crisis is effective. In conclusion, the Niger plant displays potential as a high-quality silage. It is recommended that Niger forage be silaged with varied additives and rates. Further investigations are required to establish its in vitro digestibility and animal preference in vivo.

Acknowledgments

The author would like to thank Kırşehir Ahi Evran University, the Faculty of Agriculture, the students of the Department of Agricultural Biotechnology, and also for the use of the University's Building Materials Laboratory for carrying out this research. This work was supported by Kırşehir Ahi Evran University Scientific Research Commission (Grant numbers ZRT.A4.19.007).

Conflicts of Interest

No conflicts of interest to declare.

Data Availability Statement

The original contributions presented in the study can be directed to the corresponding author.

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Figure 1

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[redacted]

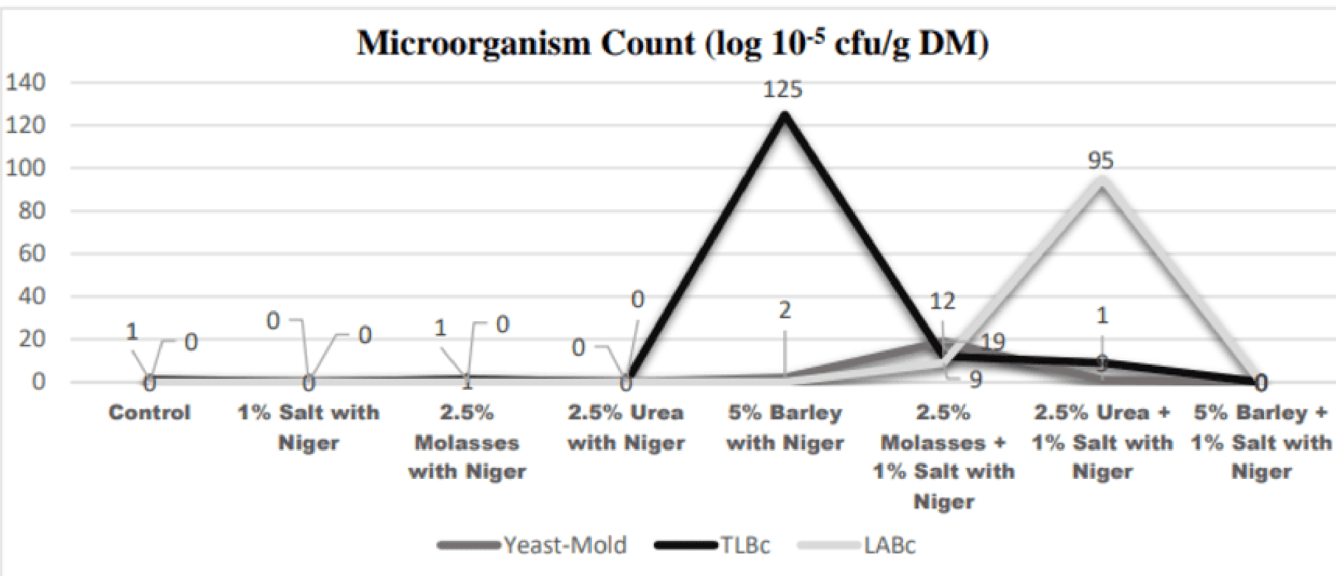

Figure I. Microbial counts of Niger silage groups

LABc: Lactic acid bacteria count and **TLBc**: Total live bacteria count.

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Table 1(on next page)

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Table I. Quality and color of Niger silages with different additives

Parameters[1]	°C	pH	WSC (°Brix)	Fleig Score	*L**	*a**	*b**	*ΔE**	*h*	*C**
Control (Niger)	22.95a	4.39a	15.50c	69.82d	25.36a	3.07	8.34ab	26.89a	69.79ab	8.91a
Niger with 1% Salt	22.98a	4.38a	15.25c	73.24cd	25.38ab	2.9	7.30abc	25.62ab	68.32ab	7.85ab
Niger with 2.5% Molasses	19.40b	4.20b	15.75bc	86.99b	24.48ab	3.39	6.99bc	25.69ab	64.39b	7.79ab
Niger with 2.5% Urea	22.90a	4.21b	16.75abc	82.79b	25.56a	2.84	8.47a	27.08a	71.51a	8.93a
Niger with 5% Barley	19.50b	4.40a	16.00abc	75.53c	24.82a	2.86	6.78c	25.89ab	67.18ab	7.37b
Niger with 2.5% Molasses + 1% Salt	19.63b	4.13bc	18.25ab	93.61a	22.70b	2.74	6.63c	23.82b	67.33ab	7.18b
Niger with 2.5% Urea + 1% Salt	23.10a	4.06c	18.50a	93.61a	24.38ab	3.25	7.68abc	25.78ab	67.09ab	8.34ab
Niger with 5% Barley + 1% Salt	19.55b	4.18b	15.50c	86.41b	25.38a	2.65	7.48abc	26.57a	70.31a	7.95ab
SED	0.037	0.014	0.284	0.583	0.218	0.096	0.148	0.249	0.600	0.967
P Value	0.0001	0.0001	0.0419	0.0001	0.0073	0.5272	0.0364	0.0848	0.1418	0.0686
Effects ¥ L	0.563	0.3408	0.7832	0.0213	0.1486	0.9495	0.0472	0.1181	0.2561	0.0645
Effects ¥ Q	0.7237	0.0001	0.0099	0.0001	0.8772	0.8229	0.5511	0.8048	0.8841	0.5632
Effects ¥ C	0.2319	0.0145	0.139	0.0043	0.3662	0.253	0.4928	0.4113	0.1329	0.7183

[1] **°C**: Celsius degree; **WSC**: water soluble carbohydrate value (Brix degree 0 - 25°); ***L****: Lightness; ***a****: Redness; ***b****: Yellowness; **ΔE***: The total color difference; **h**: hue angle and **C***: Chroma or saturation. [a,b,c,d] Means with the different letter within the same column are significantly different according to the Duncan test at (p<0.01. [¥] **L**: linear; **Q**: quadratic; **C**: cubic effects. **SED**: Standard error of the difference between 2 means.

Table II. Nutrient content of Niger silages with different additives

Parameters		DM[1-4]	OM[2]	Ash[2]	CP[2]	EE[2]	CF[2]	ADF[2]	ADFom[3]	NDF[2]	NDFom[3]
Control (Niger)		201.09e	96.58c	3.43a	4.57bc	8.23ab	27.88b	40.91a	37.49a	57.91a	54.48a
Niger with 1% Salt		217.20de	96.49c	3.52a	4.13cd	6.28c	23.28bc	37.56ab	34.04ab	50.23b	46.71b
Niger with 2.5% Molasses		248.93abc	96.46c	3.54a	4.11cd	5.34c	37.02a	37.65ab	34.11ab	25.33c	21.79c
Niger with 2.5% Urea		231.43cd	97.07b	2.93b	4.02d	6.77bc	19.52c	27.01c	24.08c	15.92de	12.99de
Niger with 5% Barley		232.14cd	96.52c	3.48a	4.77ab	6.63bc	22.44bc	34.44ab	30.96ab	18.57cde	15.09cde
Niger with 2.5% Molasses + 1% Salt		268.01a	96.64c	3.36a	5.05ab	5.53c	25.76bc	36.58ab	33.22ab	43.47b	40.11b
Niger with 2.5% Urea + 1% Salt		254.02ab	97.79a	2.22c	3.52e	9.20a	36.54a	31.10bc	28.88bc	11.05e	8.83e
Niger with 5% Barley + 1% Salt		242.55bc	96.63c	3.37a	5.22a	7.01bc	21.27bc	36.62ab	33.25ab	22.46cd	19.09cd
	SED	1.992	0.041	0.041	0.051	0.170	0.665	0.664	0.691	0.800	0.818
	P values	0.0006	0.0005	0.0005	0.0004	0.0058	0.0009	0.0152	0.0286	0.0001	0.0001
Effects ¥	**L**	0.0012	0.0244	0.0244	0.0225	0.1505	0.7111	0.0011	0.0018	0.0247	0.0001
	Q	0.0175	0.0179	0.0179	0.0041	0.1683	0.2291	0.0884	0.1307	0.0001	0.8294
	C	0.0329	0.3113	0.3113	0.1435	0.0026	0.0002	0.1299	0.1582	0.5117	0.0123

[1] g/kg natural material, [2] (%) of dry matter, [3] **ADFom**=ADF ash, **NDFom**=NDF ash; [4] **DM**: In Air Dry Matter (g/kg); **OM**: Organic Matter (%); Ash (%); **CP**: Crude Protein (%); **EE**: Ether Extract (%); **CF**: Crude Fibre (%); **ADF**: Acid Detergent Fibre (%) and **NDF**: Neutral Detergent Fibre (%). [a,b,c,d] Means with the different letter within the same column are significantly different according to the Duncan test at ($p<0.01$). [¥] **L**: linear; **Q**: quadratic; **C**: cubic effects. **SED**: Standard error of the difference between 2 means.

Table III. Energy values of Niger silages with different additives

Parameters[1, 2, 3]	NFE	NFC[1]	TC[1]	DE	ME	NE_L	NE_M	NE_G
Control (Niger)	51.55cd	42.86d	83.77d	2.35bc	1.92b	1.19b	1.08bc	0.53bc
Niger with 1% Salt	58.66ab	48.52bcd	86.08abc	2.34c	1.92b	1.18b	1.08c	0.52c
Niger with 2.5% Molasses	45.98de	49.37bc	87.02a	2.30d	1.88c	1.16c	1.04d	0.49d
Niger with 2.5% Urea	63.26a	59.27a	86.28ab	2.35bc	1.92b	1.18b	1.08bc	0.53bc
Niger with 5% Barley	59.17ab	50.68bc	85.11bcd	2.37abc	1.95ab	1.20a	1.10abc	0.55ab
Niger with 2.5% Molasses + 1% Salt	55.45bc	49.49bc	86.06abc	2.38ab	1.95ab	1.20a	1.10ab	0.55ab
Niger with 2.5% Urea + 1% Salt	44.77e	53.97ab	85.06bcd	2.28d	1.87c	1.14d	1.02d	0.47e
Niger with 5% Barley + 1% Salt	59.38ab	47.79cd	84.41cd	2.40a	1.97a	1.21a	1.12a	0.56a
SED	0.615	0.608	0.185	0.003	0.003	0.002	0.003	0.002
P values	0.0005	0.0049	0.0307	0.0003	0.0003	0.0001	0.0003	0.0001
Effects ¥ L	0.0203	0.0002	0.0068	0.5010	0.2907	0.0727	0.3395	0.3052
Effects ¥ Q	0.0192	0.2530	0.0198	0.0136	0.0353	0.0085	0.0193	0.0114
Effects ¥ C	0.0002	0.1094	0.8980	0.0110	0.0094	0.0068	0.0159	0.0111

[1] (%) of dry matter; [2] Data represent the mean of four applications of each treatment; [3] **NFE**: nitrogen-free extract (g/kg); **NFC**: non-fibre carbohydrates (g/kg) and **TC**: total carbohydrates (g/kg), **DE**: digestible energy (Mcal/kg); **ME**: Metabolizable energy (ME Mcal/kg), **NE_L**: net energy-lactation (Mcal/kg), **NE_M**: net energy-maintenance (Mcal/kg), **NE_G**: net energy-gain (Mcal/kg). [a,b,c,d] Means with the different letter within the same column are

significantly different according to the Duncan test at ($p<0.01$). ¥ **L**: linear; **Q**: quadratic; **C**: cubic effects. **SED**: Standard error of the difference between 2 means.

Table IV. Relative feed value and relative feed quality of silages from Niger with different additives

Parameters[1, 2, 3]		DDM	DMI	TDN	RFV	RFQ
Control (Niger)		43.79e	2.95c	53.21bc	100.32e	127.44c
Niger with 1% Salt		49.78d	3.23c	53.08c	124.70de	139.13bc
Niger with 2.5% Molasses		69.17c	3.19c	52.10d	171.07c	135.21c
Niger with 2.5% Urea		76.50ab	4.45a	53.23bc	263.47a	192.28a
Niger with 5% Barley		74.44abc	3.49bc	53.81ab	201.19b	152.52bc
Niger with 2.5% Molasses + 1% Salt		55.05d	3.29c	53.86ab	139.82d	143.88bc
Niger with 2.5% Urea + 1% Salt		80.29a	3.86b	51.51d	240.21a	161.62b
Niger with 5% Barley + 1% Salt		71.41bc	3.29c	54.35a	181.78bc	145.23bc
	SED	0.623	0.056	0.073	2.753	2.527
	P values	0.0001	0.0031	0.0002	0.0001	0.0045
Effects ¥	**L**	0.0001	0.3503	0.0002	0.0001	0.0003

	Q	0.7115	0.0161	0.0154	0.0024	0.0131
	C	0.0120	0.0128	0.0539	0.5098	0.0435

[1] (%) of dry matter; [2] Data represent the mean of four applications of each treatment; [3] **DDM**: digestible dry matter (%); **DMI**: dry matter intake (live weight: LW, %); **TDN**: total digestible nutrients (%); **RFV**: relative feed value and **RFQ**: relative forage quality). [a,b,c,d] Means with the different letter within the same column are significantly different according to the Duncan test at ($p<0.01$). [¥] **L**: linear; **Q**: quadratic; **C**: cubic effects. **SED**: Standard error of the difference between 2 means.