



Utilization of *Moringa oleifera* Leaves in Enhancing the Ensiling Qualities of *Triticum aestivum*

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Abstract

This study was conducted to assess ensiling qualities of Wheat forage (*Triticum aestivum*) using graded levels of *Moringa oleifera* leaves for better silage. The Wheat forage was ensiled with *Moringa* leaves at 100%, 75%, 50%, 25% and 0%, making five treatments and replicated three times. The wheat forage was harvested at early vegetative stage and chopped to 4cm length, while *Moringa oleifera* leaves at early flowering stage. The chopped wheat forage were mixed with *Moringa* leaves and ensiled for the period of 21 days in a laboratory silo and subsequently evaluated for colour, aroma and pH. Each replicate of the five treatments were sample for proximate and minerals analysis. Results revealed that silages made from the mixture of 75%Wheat forage+25*Moringa oleifera* leaves was light brown colour with very sweet aroma. Silage made from 100% *Moringa oleifera* leaves produced dark brown colour with pleasant aroma. All the silages made have pH values range from 4.22 to 5.58. Minerals (Ca, Mg and Na) were statistically significant ($P<0.05$) also increases as the level of *Moringa oleifera* inclusion increase. Silage made from 100% *Moringa oleifera* proved superior in minerals contents as compared to the others treatments. The proximate composition of silages differs significantly ($P<0.05$), silage made from 100% *Moringa oleifera* was superior in %CP, %EE and %ASH. Dry matter content was not significantly different among all the treatments. It was concluded that 75% Wheat+25% *Moringa oleifera* mixture produced better silage.

Keywords: Wheat; Silage quality; *Moringa oleifera*; Silage making; Leaves.

Introduction

Scarcity of forages are major constraints to ruminant productivity in developing Countries especially Nigeria. In most of these Countries, the natural pastures, which are the predominant basal diets are usually unobtainable in the dry season and characterized by fibrous and lignified nature with the attendant low nutritive values, resulting in limited intake, digestibility and utilization (Vincent *et al.*, 2015). Silage making is one of the methods of forage conservation practiced in livestock production systems, although it is not a common practice among the livestock producers in Nigeria. Ensiling has been reported as a viable option for preservation of excess forage during the growing season when yield and nutritional

values are optimal. Silage can be used at any period of the season when it is required, more especially during the period of shortage (Abdurrahaman *et al.*, 2018). The planting and maintenance of pastures for the feeding of livestock is an old practice in grazing systems as reported by; Muhammad *et al.*, (2009). Similarly, the inclusion of legumes to improve the ensiling quality of grasses had been explored by many authors on several grass-legume mixtures (Muhammad *et al.*, (2009), Ahmad *et al.*, 2012, Abdurrahaman *et al.* (2018). The inclusion of legumes to grass forage during feeding increases productivity, profitability and also ensures long-term sustainability of livestock production systems in the tropics (Abdurrahaman *et al.*, 2018). *Moringa* leaves have been successfully been

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used to supplement low-quality forage diets and improve animal performance, it is typically fed fresh to ruminants, similarly, the leaf powder has also received some research attention with promising results (Vincent *et al.*, 2015).

Anaerobic fermentation of soluble carbohydrates in forages results in a variety of end products, ultimately resulting in the preservation of a forage crop as silage. However, measuring the pH and quantifying the production of organic acids and alcohols are the main basis of evaluating silage fermentations (Kung *et al.*, 2018).

The recent development is, most of the grasses over used as silage materials are mainly energy valued with less protein and minerals values. This cannot meet the animal requirements, thereby resulting in loss of weight and low profit to the livestock farmers. The mixture of legumes and grasses, therefore, is one of the methods used to improve the nutritive values through ensilage (Abdurrahman *et al.* 2018). Still, limited work exist in area of irrigated pasture especially wheat and moringa. This research work was designed to examine the addition of *Moringa oleifera* leaves in Wheat forage (*Triticum aestivum*) silage, and to determine the optimum level of *Moringa oleifera* leaves inclusion for better silage.

Materials and Method

Experimental Area

The experiment was conducted at Department of Animal Health and Production, Binyaminu Usman Polytechnic, Hadejia, Jigawa State. Hadejia Local Government is one among the 27 Local Governments in Jigawa State it lies in the Northern Eastern corner of the state, latitudes 12° 13' - 13° 60' N and longitudes 9° 22' - 11° 00'E. The climate of the area is semi-arid. It is characterized by long dry season and a short wet season from June to September. The average annual temperature is 27.2°C – 38.0°C, while the total annual rainfall ranges from 600mm to 762mm, the regional vegetation falls within the Sudan Savannah type with extensive open grassland with few scattered trees (Garba *et al.*, 2016). The environment is conducive to different species of livestock production, such as cattle, sheep, goats, rabbits, donkeys, horses and poultry (JARDA, 2012). Crops grown in the region includes millet, rice, sorghum, maize, cowpea, groundnut, watermelon, tomato, soya bean, sesame and so many tree crops. Commercial agricultural products include grain of cereals and pulses, horticultural crops and livestock.

Experimental Design and Treatments

The experiment was laid out in a completely randomized design. Five treatments were evaluated with three replications per treatment, as shown in Table 1.

Table 1: Silage Treatments

Treatments	Wheat Forage (%)	Moringa Leaves (%)
T1	100	0
T2	75	25
T3	50	50
T4	25	75
T5	0	100

Silage preparation and treatment combinations

Field grown Wheat forage (*Triticum aestivum*) was cut at early vegetative stage

(28 days after planting), and it was cut manually using a sickle 4cm above the ground level to avoid soil contamination. The Moringa leaves were sampled at early flowering stage; the leaves were fresh and green. These materials were allowed to wilt for a period of 4 hours under shade and then ensilage in laboratory silos based on treatment combinations as shown in table 1:

Each of the treatment combinations above were ensilage in a laboratory silo, compressed manually until filled to the brim, grease was applied to the lids before screwed the cover

back tightly to provide anaerobic environment which is suitable for fermentation. The silos were kept at room temperature for twenty-one days incubation period.

After to 21 days incubation period, each silo was open, the content from the first 1-1.5cm of the silos were scrubbed out to prevent possible contamination by the grease used as air sealant, the content of the silos was physically examined and scored for colour and aroma by three independent specialists on a scale of 1 – 4 as described by Muhammad *et al.*, (2009).

Table 2: Description of colour and aroma rating used as indices of silage quality

Rating	Colour	Aroma
1	Dark or deep brown	Putrid or rancid
2	Light brown	Pleasant
3	Pale yellow	Sweet
4	Yellowish green	Very sweet

Source: Muhammad *et al.*, (2009).

However, pH in water was determined using digital pH meter Hanna Instruments pH210 (Microprocessor pH meter) that is 10g of sample diluted with 50ml of distilled water. After that, a sub-sample was taken from the prepared silages for proximate and minerals analysis according to the method of AOAC (1999).

Chemical Analysis

Sub-samples of the silages were oven dried and the dry matter was determined. The dried samples were ground to pass through 1mm sieve using “Tecatoscycbtee” 1093 Sample Mill. Proximate analyses of samples were carried out to determine Nitrogen (N) for crude protein, Crude fibre (CF), Ether extract (EE), and Ash contents according to AOAC (1999). Ash was obtained by ashing the samples in gallon lamp muffle funnel at 600°C for 30 minutes. Phosphorus, Calcium and Magnesium content was determined

(AOAC, 1999). Organic matter was calculated as the difference between Dry matter and Ash.

Data Analysis

Data collected were stored in Microsoft Excel office 2016 and later subjected to the General Linear Model procedures of the Systems Analytical Statistics package (SAS 2013) package and differences between means was separated using Fisher’s Least Significant (FLS) at probability level of 0.05.

Interpretation of Data from Chemical and Organoleptic Characteristics of Silage Fermentation

The most common measurements used for evaluating silage fermentation include pH; the concentrations of organic acids, alcohols, and NH₃-N; and the size of various microbial populations. In an ideal fermentation, homolactic acid bacteria use water-soluble carbohydrates (e.g., glucose) for growth and

produce only lactic acid, resulting in a relatively high recovery of DM and energy (Kung *et al.*, 2018). However, the fermentation of forage crops is very complex and involves many types of microorganisms, resulting in variety of different end products. Well-fermented silages should not have a strong, particular odor because lactic acid the main organic acid from the fermentation is nearly odorless. However, most silage tends to have a mild odor of vinegar (acetic acid) because this acid is produced in the second highest concentration after lactic acid and is very volatile. Smelling silages with very high concentrations of acetic acid will often leave a burning sensation in one's eyes and nose. Besides the smell of vinegar, wet silage with excessive acetic acid also presents a yellow color, especially at the bottom of a silo because the influence of compaction will further increase the moisture content in this area (Kung *et al.*, 2018).

Results and Discussion

Results

The pH of an ensiled sample is a measure of its acidity. Whole-plant corn and alfalfa have pH levels that range from about 5.5 to 6 immediately after chopping. During ensiling, lactic acid, produced by lactic acid bacteria (LAB), is usually the acid found in the highest concentration in silages, and it contributes the most to the decline in pH during fermentation because it is about 10 to 12 times stronger than any of the other major acids [e.g., acetic acid and propionic acid] found in silages (Kung *et al.*, 2018). Several factors can be responsible for silages that present a pH that is higher than normal. For example, an abnormally high buffering capacity (e.g., in legume silages with very high protein and ash contents) or a restricted fermentation (e.g., cold climatic conditions) may be the cause of a higher than expected pH (Kung *et al.*, 2018). Chemical composition and physical properties of silages

is imperative for appropriate ration preparation and troubleshooting silage quality problems; capacious literature exists on this topic (Kung and Shaver, 2002; Heinrichs and Kononoff, 2013; Abubakar *et al.*, 2018). The content and fermentability of silage fiber, starch, and protein, together with fermentation end products, influence ruminant animal feeding behavior and dry matter intake (Oliveira *et al.*, 2017).

Table 3 presented physical feature of Wheat forage silage with different levels of Moringa leaves mixtures. Colour and aroma give indices to assess quality silage. In terms of colour and aroma, better silage was made from T1:100% wheat forage, a deep brown colour with a very sweet aroma product. Silage made with inclusion of 25% Moringa leaves and 75% wheat forage (T2) resulted in a light brown colour with very sweet aroma. Nevertheless, silage made from 100% moringa (T5) produced product with dark brown colour and pleasant aroma.

Level of moringa inclusion affected the pH values of the silage significantly ($P < 0.05$). The pH values obtained were 4.22 in T5 and 5.58 in T2. It was observed that as the level of Moringa leaves inclusion increased the pH values of the compounded silage decreased to acidity. Legume silages with high ash contents ($>15\%$) also are sometimes very high in acetic acid because of prolonged fermentations (Kung *et al.*, 2018).

Table 4 showed the proximate composition of silage prepared from wheat with graded level of moringa. All parameters evaluated were statistically significant ($P < 0.05$) except dry matter which was not. T1 (Sole wheat) was the lowest in terms of CP (10.20%), EE (2.80%) and ASH (6.70%), while treatments with sole moringa (T5) resulted in higher contents of %CP; 20.60, %EE; 6.70 and %ASH 14.20. While in terms of %CF T1 has

the highest value 28.50 and T5 resulted in lowest value 16.30.

Table 3: pH value, colour and aroma of wheat silage at different levels of moringa inclusion

Treatments (%)	pH	Colour	Aroma
T1	5.13 ^b	1	4
T2	5.58 ^a	2	4
T3	4.40 ^d	3	3
T4	4.71 ^c	2	2
T5	4.22 ^e	1	2
SE±	0.04		

a, b, c, d Means with different superscripts along columns differ significantly at (P < 0.05) Colour: 1= Yellowish green, 2= Pale yellow, 3=Light brown, 4= Dark brown. Aroma: 1 = Putrid, 2 = Pleasant, 3 = Sweet, 4 = Very sweet.

Table 4: Proximate composition of Wheat silage ensiled with graded levels of moringa.

Treatments	%DM	%CP	%CF	%EE	%ASH
T1	94.00 ^a	10.20 ^e	28.50 ^a	2.80 ^e	6.70 ^e
T2	93.60 ^a	11.00 ^d	25.20 ^b	3.70 ^d	8.20 ^d
T3	93.00 ^a	11.90 ^c	22.90 ^c	4.68 ^c	10.10 ^c
T4	92.60 ^a	12.80 ^b	19.60 ^d	5.60 ^b	11.60 ^b
T5	92.00 ^a	20.60 ^a	16.30 ^e	6.70 ^a	14.20 ^a
SE±	0.64	0.13	0.40	0.13	0.15

a, b, c, d Means with different superscripts along columns differ significantly at (P < 0.05) DM = Dry Matter, CP = Crude Protein, CF = Crude Fibre, EE = Ether Extract, ASH = Ash, CHO = Soluble Carbohydrate and OM = Organic matter.

There were significant differences statistically (P < 0.05) in the Ca, Mg and Na contents of the compounded silages. T5 (sole Moringa) leads in Ca (0.9906), Na (0.9507) and Mg (0.4479) compared to other treatments, while T1 was the least Ca and Na. This shows that, as the level of legume inclusion increased the Ca and Na contents of all the treatments also increase.

Table 5: Mineral contents of Wheat silage ensiled with graded levels of *Moringa oleifera*.

Treatments (%)	Ca (ppm)	Mg (ppm)	Na (ppm)
T1	0.3351 ^e	0.3413 ^a	0.6757 ^e
T2	0.6788 ^d	0.2793 ^a	0.7302 ^d
T3	0.8773 ^c	0.3984 ^a	0.7867 ^c
T4	0.9030 ^b	0.4182 ^a	0.8349 ^b
T5	0.9906 ^a	0.4479 ^a	0.9507 ^a
SE±	0.0008	0.0862	0.0003

a, b, c, d Means with different superscripts along columns differ significantly at (P < 0.05) P = Phosphorus, Ca = Calcium, Na = Sodium

Discussion

The inclusions of legumes in grass silage are suitable, through which the deficiency of protein in grass and low level of carbohydrate in legumes are overcome (Muhammad *et al.*,

2009 and Abdurrahman *et al.*, 2018). Choice of the different species of legume for inclusion in grass silage will depend on its concentration, nutrients and yield per unit area (Muhammad *et al.*, 2008).

pH value is one of the simplest ways of evaluating silage quality. Silage that has been properly fermented will have a much lower pH (Abdurrahaman *et al.*, 2018). According to Kung and Shaver (2002) in their interpretation of silage analysis stated that a good quality grass and legume silage pH values in the tropics ranges between 4.3 – 4.7. Silages prepared with 75%wheat+25%moringa give high pH value of 5.58 while silages with 50%wheat+50%moringa (T3;4.40) and 25%wheat+75%moringa (T4;4.71) resulted in moderate pH values. Low pH value was recorded in sole moringa silage: T5 (4.22), which is an indication of poor fermentation and low quality with dark or deep brown but with pleasant aroma which is different with what Abdurrahaman *et al.*, (2018) reported (dark colour rancid aroma).

Silage quality can also be evaluated physically through colour, aroma and by chemical analysis (Abdurrahaman *et al.*, 2018). The light brown colours with very sweet aroma obtained in the treatment combination of 75%wheat+25%moringa leaves. Dark brown colour with rancid aroma were obtained in the 100%Legume silages as reported by Abdurrahaman *et al.*, (2018) which was different with the present result in sole Moringa leaves silage T5 (i.e deep brown colour with pleasant aroma). The results for aroma obtained in this study compares with the reports of several authors (Menenses *et al.*, 2007; Oduguwa *et al.*, 2007; Muhammad *et al.*, 2009; Baba *et al.*, 2010 and Inyang *et al.*, 2012), all reported that the end product of good silage had a pleasant or sweet aroma. Amodu and Abubakar (2004) stated that good silage usually has an acceptable aroma (clean and not putrid odour).

Crude Protein content of the compounded silage range from 10.20 - 20.60%, this agreed with results reported by Abdurrahaman *et al.*, (2018), and Muhammad *et al.* (2007, 2008) that showed high CP contents of the silages made from high legumes inclusion. Increase in the level of moringa inclusion in the silages resulted in increased percentage of CP, EE and ASH with corresponding decline in %CF in all treatments.

Crude Protein (CP) values of (10.20) realized for the sole wheat forage silage was higher as compared with what Abdurrahaman *et al.*, (2018) reported (2.80). This suggests that inclusion of Moringa leaves improved the ensiling quality of wheat forage silage as reported by Azim *et al.* (2000), Mthiogene *et al.* (2001), Muhammad *et al.* (2008, 2009) and Abdurrahaman *et al.* (2018).

The mineral contents (Ca and Na) evaluated were higher than the values reported by Abdurrahaman *et al.*, (2018) for Gamba grass mixed with legumes (Groundnut, Watermelon and Cowper). This could be relating to soil and level of fertilizer applied in the field.

Conclusion

Combination of *Moringa oleifera* leaves and *Triticum aestivum* forage has beneficial advantage to silage quality. The outcomes obtained from this work shown that the level of *Moringa oleifera* leaves inclusion at 25% gives better quality silage with moderate pH values and very sweet aroma. However, 100% *Moringa oleifera* leaves silage resulted in low pH, dark brown colour and pleasant aroma.

Recommendation

Further research work should be carried out in feeding trials and health benefit in feeding *Moringa oleifera* leaves silage.

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