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EVALUATION OF FINGER MILLET (*Eleusine coracana L.*) FODDER PRODUCTION AND UTILIZATION BY DAIRY GOATS IN A SEMI-ARID ENVIRONMENT OF NIGERIA

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ABSTRACT: The study was conducted to determine the nutritional quality of finger millet silage and its impact on performance of Sahel dairy goat. The experiment was divided into three phases and carried out at University of Maiduguri pasture farm. Experiment I consisted of eight treatments (four different spacings and four cutting ages), experiment II had five different finger millet silages and experiment III constituted five different finger millet based total mixed ration (TMR) as treatments which was laid out in a completely randomized design (CRD). Plant height, leaf number, leaf length, leaf width and tiller count were recorded as influenced by spacing and cutting age in phase I, physical characteristics of the silage and its proximate composition was observed in phase II while feed intake, milk yield and proximate composition of the milk was recorded in phase III. The results revealed that at 21 days after ensiling, the appearance, odour, texture, pH and temperature of the silage had acceptable physical characteristics across the treatments. The results further revealed that plant height (36.54 cm), leaf number (29.95 cm), and leaf length (33.61 cm) were significantly ($P<0.05$) higher in T4 (30 x 10 cm) while leaf width and tiller number was similar ($P>0.05$) among the treatments. The findings also indicated that plant cut at 10 WAS had the highest (36.92 cm), plant height (30.30 cm), and leaf number (28.47 cm). The results revealed that the highest average milk yield (0.91 litre) was observed in T4 and the milk quality was equally better in T4. In conclusion, finger millet performed best at 30 x 30 cm spacing and cutting age was best at 10 weeks after sowing, the nutritional quality and the silage physical quality was best at 12 – 20% inclusion level and improved milk production by Sahelian dairy goats.

Key words: finger millet, fodder, dairy goat,

INTRODUCTION

Finger millet (*Eleusine coracana* L.) Gaertn. ssp. coracana) is the second most popular millet farmed in Africa. It is a significant crop that resource-poor farmers in eastern and southern Africa cultivate in low-input farming methods (Damar *et al.,* 2016). Native to the highlands of Ethiopia and Uganda, finger millet is commonly grown and consumed locally by small-scale farmers (Adugna *et al.,* 2011). Due to its adaptability to low soil fertility, excellent biomass production capacity, rapid growth, tolerance to acid sandy soils, and ability to grow on saline soils. Additionally, it grows during the dry season or in regions prone to dry spells and droughts (Gupta *et al.,* 2017), which are conditions under which sorghum (Sorghum bicolor L. moench) or maize (Zea mays L.) would not develop satisfactorily (Vertriventhan *et al.,* 2020).

In semi-arid areas, the rainfall is brief and fluctuates seasonally, which makes it difficult to maintain natural forage production for long period along the year. Preserving forage in the form of silage is thus one of the options to provide high-quality feed to animals despite seasonal climatic changes. The nutritional values of finger millet are comparable with those of forage plants traditionally used for silage production such as maize and sorghum. Additionally, the silage quality of finger millet can be further increased through the use of chemical additives during ensiling such as urea, poultry litter, urea and molasses (Afolayan, 2022).

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Goats play important roles in the livelihoods of pastoralists in sub-Saharan Africa (Kosgey and Okeyo, 2016). These roles include provision of meat and milk as mainstream protein sources, blood used for food in some pastoralist communities (Miller, 2019). The skins are used for making shoes and bags in leather industry, economic safety net and acting as a bridge into production of large livestock (Kosgey *et al.,* 2016 and Aziz, 2010). The role of goats in provision of these services remains unparalleled especialsly in marginal areas owing to their high level of adaptability to harsh production conditions and continuous climatic changes (Agussou *et al.,* 2017) as well as the progressive increase in human population that is leading to decline in arable land. These roles are underestimated in many instances. Due to their adaptability, these animals can be found virtually in all agro-ecological zones in sub-Saharan Africa.

MATERIALS AND METHOD

Experimental Site

The Pasture Unit and Livestock Teaching and Research Farm of the Department of Animal Science, Faculty of Agriculture, University of Maiduguri, Maiduguri, Borno State, Nigeria, was the location of the experiment. The semi-arid region lies in West Africa's Sahel zone, which is renowned for its extreme weather and seasonal variations. There are essentially two separate climate seasons in the city each year. These are: a lengthy dry season that lasts from October to May, and a brief wet season that typically lasts from June to September. The warmest months of the year are March, April, and May, when temperatures range from 30 to 43 degrees Celsius. A dip in temperature occurs during the rainy season, when temperatures range from 25 to 30 degrees Celsius. The temperature drops significantly during the harmattan months, which takes place between October and February. Extreme temperatures of 43°C and 20°C have been seen in June. August has a relative humidity of roughly 45%, while the drier months of December and January have a relative humidity of roughly 5% (Lake Chad Research Institute, 2015).

Phases of Experiment

The experiment was divided into three phases.

Phases I

Finger Millet Fodder Production

Experiments and Experimental Design

The treatments for this experiment consisted of four different spacing (60x16 cm, 50x14 cm, 40x12 cm and 30x10 cm inter and intra raw spacing, respectively) which were replicated three times. The treatments were laid out in a split split factorial design. The total area for the trial was 33.5x33.5 m (1122.25 m^2) with plot size per treatment of 8 m^2 while the space between each plot was 0.5 m.

Agronomic Practices and Data Collection

The land was cleared of thorns; dry weeds, debris etc with the aid of hoe, axe and cutlass, then ploughed and leveled on 29th June, 2023. The finger millet was propagated by sowing at 5 cm depth using 60x16 cm, 50x14 cm, 40x12 cm and 30x10 cm inter and intra row spacing. After 3 weeks of sowing, dead plants were replaced to ensure 100% fodder population and seedlings were thinned to 3 stands per hole to reduce competition. Weeding was done at two weeks interval and NPK (15:15:20) fertilizer was equally applied after weeding. The cuttings were done fortnightly from 6 weeks post planting and parameters measured were plant height, number of tillers, leaf number, leaf length and leaf width. Harvesting was done at bloomy stage for silage making.

Phase II

Silage Making

Finger millet was cut at the University of Maiduguri, pasture farm. Molasses was sourced from Numan sugar industry, Adamawa state, Nigeria. The finger millet was wilted for 24 hours and chopped to 3 – 5 cm. The chopped finger millet

and molasses were mixed at different rates to come up with five treatments, compressed and poured into polyethene bags and allowed to stand for 21 days. At 21 days ensiling period, the polyethene bags were opened and physical parameters such as pH, temperature, texture, odour and appearance were observed as described by Lamidi and Akhigbe (2022). Table 1 displays the proportions in percentage terms.

Phase III

Feeding Trial
Experimental Design

The experiment consists of five (5) treatments laid out in a Completely Randomized Design (CRD) and each treatment allotted with 3 goats serves as replicate making fifteen (15) goats.

Experimental Animals and Management
For this investigation, 15 Sahelia goats were utilized. Before the trial began, the animals were dewormed and given prophylactic treatment with 5% Ivermitin, 20% oxyted L.A., multivitamin and diaminazine acetate. The animals were prepared for the experiment by feeding them the experimental diet for two (2) weeks for adaptation before the experiment started. The animals were kept in pens with large windows for natural light.

Experimental Design and Feeding
The goats were allocated to treatments at 3 goats per treatment. The goats were balanced for weight before commencement of the experiment and weighed weekly thereafter throughout the experimental period. The experimental diets (Table 2) were offered at 4% of body weight while groundnut haulm was fed ad libitum as basal diet. Feed intake was determined as the difference of the amounts of feed offered and the refusals. Water was offered daily and the milk yield was measured by manual milking of the goats and the experiment lasted for 84 days (12 weeks).

Analytical Technique
The data obtained were subjected to analysis of variance (ANOVA) and the differences among the means were compared using Least Significant Difference (LSD) at 5% level of probability.

RESULTS AND DISCUSSION

Table 1: Gross composition of finger millet based total mixed ration (TMR)

Ingredients	T1	T2	T3	T4	T5
Maize bran	10	10	10	10	10
Cotton S. C.	17	17	17	17	17
G. Haulms	20	20	20	20	20
F. millet silage	50	50	50	50	50
Bone meal	2	2	2	2	2
Salt	1	1	1	1	1

Table 2: Gross composition of finger millet silage

Ingredients	T1	T2	T3	T4	T5
Finger millet	56%	52%	48%	44%	40%
Poultry litter	30%	30%	30%	30%	30%
Water	10%	10%	10%	10%	10%
Molasses	4%	8%	12%	16%	20%

Physical Characteristics of Silage
There was difference in odour, temperature and pH among the treatments. Silage from T_2 and T_3 had the same olive green appearance and characterized with very pleasant odour and firm texture. The green olive appearance and firm texture of the silage observed in T_2 and T_3 is an indication of good quality silage which could be attributed to application of doom palm and cane sugar molasses as a source of soluble carbohydrate. Temperature observed across the treatments in this study was within the recommended range (26.1 to 29.1°c). Temperature of silage above 30°c

could result in silage with dark appearance as a result of caramelization of soluble carbohydrates in the ensiled material. The pH values (3.40 to 5.20) are within the recommended pH range (3.50 to 5.50) for good quality silage.

Table 3: Physical characteristics of the silages

Characteristics	T1	T2	T3	T4	T5
Appearance	Yellowish	Olive green	Olive green	Olive green	Olive green
Odour	Pleasant	Very pleasant	Very pleasant	Very pleasant	Very pleasant
Texture	Firm	Firm	Firm	Firm	Firm
Temperature	29.1°c	26.1°c	27°c	26.1°c	27°c
pH	5.20	3.40	3.77	3.40	3.77

Effect of Plant Spacing on Growth Component of Finger Millet

The effect of spacing on growth component of finger millet is presented in Table 3. The result reveals that there was significant (P<0.05) difference among the treatments in all the growth parameters except leaf width and tiller number. The highest plant height (36.54 cm), leaf number (29.95 cm) and leaf length (33.61 cm), was observed in T4 while the lowest (29.81, 22.05 and 22.67 cm, respectively) was recorded in T1. The results further revealed that there was no significant (P>0.05) difference among the treatments with respect to leaf width and tiller number. The values for leaf width and tiller number ranged from 0.65 to 2.11 and 3.86 to 7.53, respectively.

The results also revealed that the values for growth component increased as the spacing became wider. This could be attributed to reduction in competition among the plants and attaining of optimum plant population. The values of tiller number and number of leaves obtained from this study are higher than those (7.0 and 9.0 reported by Mulualem *et al*. (2021).

Table 4: Effects of spacing on growth component of finger millet

Spacing(cm) Inter & intra	Plant height	Leaf Number	Leaf Length	Leaf width	Tiller Number
T1 (60x16)	29.81^{b}	22.05^{b}	22.67^{d}	0.65	3.86
T2 (50x14)	34.80^{a}	24.20^{b}	27.72^{b}	0.65	4.79
T3 (40x12)	35.34^{a}	28.31^{a}	30.42^{b}	0.66	6.04
T4 (30x10)	36.54^{a}	29.95^{a}	33.61^{a}	2.11	7.53
SEM	1.22*	1.79*	1.48*	0.63^{ns}	1.36^{ns}

^{abcd}=Means with different superscript within rows differed significantly (p<0.05), SEM = Standard error of mean.
WAS= week after sowing

Effects of Cutting Age (4, 6, 8 and 10 WAS) on Growth Component

The effect of cutting age on growth component is presented in Table 4. The results revealed that there was significant (P<0.05) difference among the treatment except leaf width and tiller number. Taller plants (36.92 cm), highest number of leaf (28.47) and longer leaf (30.30) was observed in 8 and 10 weeks after sowing. The results also revealed that there was no significant (P>0.05) difference among the treatments in respect to leaf width and tiller number. The values for leaf width and tiller number ranged from 4.02 to 7.37 cm and 0.62 to 2.11 cm, respectively. The higher plant height, leaf number and leaf length observed in 10 weeks after sowing could be due higher vegetative growth due to advancement in age by the crops.

Table 5: Effects of cutting age (4, 6, 8 and 10 WAS) on growth component

Cutting age (cm) WAS	Plant height	Leaf Number	Leaf Length	Leaf width	Tiller Number
Week 4	31.47^{b}	22.85^{c}	28.50^{b}	7.37	0.62
Week 6	31.78^{b}	25.85^{b}	27.56^{b}	4.02	0.65
Week 8	36.32^{a}	27.64^{a}	28.05^{a}	5.90	0.68
Week 10	36.92^{a}	28.47^{a}	30.30^{b}	5.74	2.11
SEM	1.22^{*}	1.79^{*}	1.48^{*}	0.63^{ns}	1.36^{ns}

^{abcd}=Means with different superscript within rows differed significantly (p<0.05), SEM = Standard error of mean.
WAS= week after sowing, ns= Non Significant

Performance of Dairy Goats Fed Finger Millet Based Total Mixed Ration (TMR)

The performance of dairy goat fed finger millet silage based TMR is presented in Table 5. The results showed that there was significant (P<0.05) difference among the treatments except average feed intake. The results showed that the average feed intake was statistically similar (P>0.05) among treatment and the values ranged from 0.83 to 1.35 kg. The highest milk yield (0.95 litres) was significantly (P>0.05) recorded in T5 while the least (0.50 litre) was observed in T1. The higher milk yield observed in T5 could be due to improved nutrition enhanced as a result of incorporation of molasses during the silage production.

Table 6: Performance of dairy goats fed finger millet based total mixed ration (TMR

Parameters	T1	T2	T3	T4	T5	SEM
Days in milk	14 days	14 days	14 days	14 days	14 days	
Average feed intake (kg)	1.17^{a}	0.90^{a}	0.83^{a}	1.16^{a}	1.35^{a}	0.582
Average milk yield (litre)	0.50^{c}	0.72^{b}	0.77^{ab}	0.91^{ab}	0.95^{a}	0.223

Means followed by the same letter(s) in the same column are statistically similar using least significant difference (LSD) at 5% level of probability. T1 – 4% molasses finger millet silage based total mixed ration, T2 - 8% molasses finger millet silage based total mixed ration, T3 - 12% molasses finger millet silage based total mixed ration, T4 - 16% molasses finger millet silage based total mixed ration and T5 - 20% molasses finger millet based total mixed ration

Proximate Composition of Finger Millet Silage

The chemical composition of the finger millet silage is presented in Table 5. The results showed that there was significant (P<0.05) difference among the treatment except NFE. The highest dry matter was recorded in T4 (94.30%) followed by T5 (92.24%) while the least (94.20%) was recorded in T2. The highest Dry matter (DM) value observed in T4, T3 and T1 indicated good storage quality. The highest CP (13.14%) content was observed in T5 while the lowest (8.57%) was recorded in T1. The highest CP observed in T5 could be attributed to the higher inclusion of poultry litter during the silage making. The results also indicated that the highest NFE (57.75%) was recorded in T4 while the least (38.07%) was observed in control. The higher values for NFE observed in T4 could be due to incorporation of the molasses in the silage. The highest NDF (27.33%) and ADF (11.00%) were observed in T1 while the least (16.06 and 7.47%, respectively) was recorded in T5. The low NDF and ADF values observed across the silage could be due to the lower age of the crops ensiled leading to high quality or low fiber fraction. This work is in line with the work of Soomro (2023) and Bot *et al.* (2020).

Table 7: Proximate composition of finger millet silage

Treatments	DM	MC	CP	EE	CF	ASH	NFE	NDF	ADF
T1	94.20^{a}	5.32^{b}	8.57^{e}	2.00^{ab}	25.00^{ec}	2.50^{b}	38.07^{a}	27.33^{a}	11.00^{a}
T2	91.24^{c}	5.40^{b}	9.54^{d}	1.00^{b}	26.00^{b}	6.00^{a}	42.54^{a}	19.20^{ab}	10.00^{ab}
T3	94.30^{a}	5.28^{b}	11.03^{c}	3.00^{a}	22.33^{d}	6.00^{a}	42.53^{a}	19.00^{ab}	9.01^{abc}
T4	94.30^{a}	5.40^{b}	12.25^{b}	1.00^{b}	39.00^{a}	5.50^{a}	57.75^{a}	16.06^{b}	8.07^{bc}
T5	92.24^{b}	7.36^{a}	13.41^{a}	1.00^{b}	23.20^{cd}	2.50^{b}	40.91^{a}	17.00^{b}	7.47^{c}
SEM	0.780	1.117	0.528	1.202	1.863	1.344	24.037	8.705	2.156

Means followed by the same letter(s) in the same column are statistically similar using least significant difference (LSD) at 5% level of probability. T1 – 4% molasses finger millet silage, T2 - 8% molasses finger millet silage, T3 - 12% molasses finger millet silage, T4 - 16% molasses finger millet silage and T5 - 20% molasses finger millet silage

Proximate Composition of Finger Millet Silage Based Total Mixed Ration (TMR)

The proximate composition of the finger millet silage is presented in Table 6 . The results showed that the highest dry matter (94.60%), crude protein (11.92%) and NDF (2.67%) in T4 when compared with other treatment groups. The higher dry matter content (94.60%) was observed in T4 followed by T2 (94.04%) while the lowest (91.40%) was observed in T3. The higher dry matter observed in T4 is an indication of good storage condition. The results further revealed that the highest crude protein content (11.92%) was recorded in T4 but there was no significant (P> 0.05) difference among T1, T2, and T4 in respect to their CP than followed T3 (10.50%) while the lowest (10.41%) was recorded in T5. The higher CP (11.92%) in T4 could be attributed to the inclusion level of cotton seed cake CSC in the diet. The also indicate that the crude fiber CF was highest (27.50%) (27.00%) was recorded in T5, T4 and T3,

respectively, followed by T2 (16.50%) while the T1 (13.00%). The variation observed in the CF among the treatment could be due to sample error.

The highest Nitrogen free extract (49.50%) content followed by T4 (40.42%), T3 (40.41%), T2 (31.79%) while the lowest (29.29%) was observed in T1. The higher NFE value observed in T5 could be attributed to the inclusion of higher volume of molasses during silage making. The results indicate that the CP observed in this study across the treatments are above the maintenance requirement of 7.5% CP. The NFE content of the feed was influenced by the inclusion of the molasses and they are observed to be higher in the diets contain higher levels. This work is similar with the work of Achara *et al.* (2022).

Table 8: Proximate composition of finger millet silage based total mixed ration (TMR)

Treatments	DM	MC	CP	EE	CF	ASH	NFE	NDF	ADF
T1	93.80^{b}	6.20^{b}	11.29^{a}	3.00^{a}	13.00^{c}	2.00^{c}	29.29^{d}	19.00^{b}	8.50^{b}
T2	94.04^{b}	5.90^{bc}	11.26^{a}	1.00^{c}	16.50^{b}	3.00^{bc}	31.79^{c}	16.00^{c}	11.00^{ab}
T3	91.40^{c}	8.60^{a}	10.41^{ab}	2.00^{b}	27.00^{a}	6.00^{a}	40.41^{b}	20.06^{b}	9.50^{ab}
T4	94.60^{a}	5.40^{c}	11.92^{a}	2.00^{b}	27.00^{a}	5.50^{a}	40.42^{b}	32.67^{a}	11.43^{a}
T5	93.90^{b}	6.06^{b}	10.50^{ab}	1.00^{c}	27.50^{a}	3.50^{b}	49.50^{a}	19.66^{b}	9.00^{ab}
SEM	0.276	0.555	0.379	0.026	2.143	1.344	1.971	1.557	2.791

Means followed by the same letter(s) in the same column are statistically similar using least significant difference (LSD) at 5% level of probability. T1 – 4% molasses finger millet silage based total mixed ration, T2 - 8% molasses finger millet silage based total mixed ration, T3 - 12% molasses finger millet silage based total mixed ration, T4 - 16% molasses finger millet silage based total mixed ration and T5 - 20% molasses finger millet based total mixed ration

Proximate Composition of Dairy Goat Milk Fed Finger Millet Silage Based Total Mixed Ration (TMR)

The proximate composition of dairy goat milk fed finger millet silage based total mixed ration (TMR) is presented in Table 4. The results showed that there was significant (P>0.05) difference among the treatments except moisture content. The moisture content was similar (P>0.05) among the treatments and the values ranged from 7.33 to 8.25%. The results also showed that the crude protein and ether extract content of the milk was highest in T3 (45.9%) and T4 (34.49%) when compared with the other treatments. The higher crude protein level content observed in T3 and T4 could be attributed to the inclusion of poultry litter in the silage. Highest ash (13.50%) and carbohydrate (26.49%) was recorded in T1, followed by T3 (10.43 and 21.82%, respectively) while the least (5.56 and 21.82%) was recorded in T2. The higher ash and carbohydrate content observed in the milk of goats fed T4 and T5 diets could be attributed to the higher inclusion of molasses in the silage.

The results indicate that the variation in the quality of milk among the treatments could be due to variation in the composition of the diet fed. This means that in cooperation of molasses in the small ruminant diet has impact on milk yield. The results of this work agreed with those of Bot *et al.* (2023).

Table 9: Proximate composition of dairy goat milk fed finger millet silage based total mixed ration (TMR)

Treatment	MC	CP	EE	ASH	CHO
T1	7.34^{a}	42.72^{b}	27.43^{d}	7.58^{c}	21.82^{d}
T2	7.53^{a}	36.66^{e}	28.49c	5.56^{d}	23.41^{b}
T3	7.90^{a}	45.93^{a}	34.49^{a}	13.50^{a}	26.49^{a}
T4	8.25^{a}	38.40^{d}	32.35^{c}	10.43^{b}	23.00^{bc}
T5	7.33^{a}	40.67^{c}	26.38^{e}	7.30^{c}	22.55^{cd}
SEM	1.528	0.569	0.962	0.667	0.754

Means followed by the same letter(s) in the same column are statistically similar using least significant difference (LSD) at 5% level of probability. T1 – 4% molasses finger millet silage based total mixed ration, T2 - 8% molasses finger millet silage based total mixed ration, T3 - 12% molasses finger millet silage based total mixed ration, T4 - 16% molasses finger millet silage based total mixed ration and T5 - 20% molasses finger millet based total mixed ration

CONCLUSION

In conclusion, finger millet performed best at 30 x 30 cm spacing and at cutting age of 10 weeks after sowing. The nutritional quality and the finger millet silage physical quality was best at 12 – 20% molasses inclusion level and improved milk production performance of Sahelian dairy goats fed the finger millet silage based total mixed ration.

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