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Research Article

Effects of Maize Bran and Molasses Additives on Fermentation Quality, Nutritive Value and Digestibility of *Chloris gayana* and *Tripsacum laxum* Silages

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Abstract

This study evaluated the effects of maize bran and molasses additives on the silage quality of Rhodes grass (*Chloris gayana*) and Guatemala grass (*Tripsacum laxum*) as a strategy for improving feed availability during the dry season among smallholder dairy farmers in Mpwapwa District, Tanzania. The experiment was conducted at the Livestock Training Agency (LITA), Mpwapwa using a Completely Randomized Design (CRD) with three treatments: grass without additive (control), grass with 10% maize bran, and grass with 3% molasses. The silages were ensiled for 21 days and analyzed for chemical composition, in vitro digestibility, metabolizable energy, pH, and organoleptic characteristics. Results showed that additive treatments significantly ($P < 0.05$) improved silage quality compared to the control treatment. Maize bran treatment produced the highest crude protein, ether extract, in vitro dry matter digestibility (IVDMD), in vitro organic matter digestibility (IVOMD), and metabolizable energy values in both forage species, while reducing fibre fractions such as neutral detergent fibre (NDF) and acid detergent fibre (ADF). Molasses treatment also improved fermentation and nutritive quality, although its effects were generally lower than maize bran. Control treatments recorded higher fibre contents and lower digestibility and energy values, indicating poor fermentation quality. Silage pH was significantly reduced by additive application, with molasses-treated silage recording the lowest pH values, indicating improved lactic acid fermentation and preservation. Organoleptic evaluation revealed that maize bran-treated silage had superior colour, smell, texture, and taste scores compared to the control treatment. Rhodes grass silage generally showed better fermentation quality, digestibility, and nutritive value than Guatemala grass silage across treatments. The study concludes that maize bran and molasses are effective additives for improving tropical grass silage quality, with maize bran showing the greatest overall improvement in nutritional and sensory characteristics. Therefore, the use of maize bran and molasses during ensiling is recommended for smallholder dairy farmers to improve feed conservation and livestock productivity during dry seasons.

Keywords

Silage, Rhodes Grass (*Chloris Gayana*), Guatemala Grass (*Tripsacum Laxum*), Maize Bran, Molasses, In Vitro Digestibility

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1. Introduction

Dairy production has been contributing significantly to poverty alleviation and reduction of malnutrition particularly among the smallholder dairy farmers in rural areas [1]. However, the productivity of dairy cattle in the country is rather low, producing on average about 6 -7 liters of milk per day in the wet season and decline to nearly 3 liters per day in the dry season [2]. This is attributed mainly by inconsistent supply of forages throughout the year.

Feed quality declines rapidly early in the dry season, followed by a reduction in quantity, as a result of high grazing pressure and senescence. For example, crude protein of mature grasses declines to 1-2% during the dry season; digestible protein and phosphorus are often less than 1g/kg dry matter (DM), calcium 1.5 to 3.0g/kg DM, and carotene less than 1 mg/kg DM [3]. Even where forages are available, their digestible energy and protein content are very low, while lignin and indigestible fibers are higher than recommended [4]. These challenges result in year-round fluctuations in nutrient supply, which impair ruminant growth and productivity [5].

It is well known that during the wet season there is a flush growth of both natural forages and a notable increase in biomass of the fodder gardens around the smallholder dairy farmers' homestead [6]. The smallholder dairy farmers however, are not able to utilize most of the forage biomass present in the wet season because they lack appropriate and simple technologies for conserving these excess fodder grasses. If these fodder grasses are left in the field to mature, they loose nutritive value thereby resulting in wastage of valuable feed resource.

Despite the availability of substantial forage biomass during the wet season, the lack of efficient preservation techniques such as hay and silage making remains a major constraint among smallholder dairy farmers [7]. Consequently, a large proportion of the excess forage is underutilized, leading to seasonal feed shortages that directly affect livestock productivity [8]. In addition, limited knowledge, high labor requirements, and inadequate access to appropriate technologies further hinder the adoption of improved feed conservation practices [7].

Moreover, climate variability and recurrent drought conditions exacerbate the problem by shortening the duration of forage availability and reducing pasture regeneration capacity [34]. This increases dependence on low-quality crop residues and natural pastures during the dry season, which are insufficient to meet the nutritional requirements of dairy cattle [7]. As a result, animals experience weight loss, reduced milk yield, poor reproductive performance, and increased susceptibility to diseases [5].

To address these challenges, several strategies have been recommended, including the integration of improved forage species, use of agro-industrial by-products, supplementation with protein and mineral concentrates, and adoption of feed conservation technologies such as silage and hay making. Improved pasture management practices, including rotational grazing and controlled stocking rates, are also essential to ensure sustainable utilization of available resources.

However, despite these interventions, adoption rates among smallholder farmers remain low due to socio-economic constraints, lack of extension services, and limited awareness. Therefore, there is a need for context-specific, low-cost, and easily adoptable feeding strategies that can help bridge the seasonal feed gap and improve dairy productivity. This study therefore aims to valuate different additives effects on silage making of two forage spp *Chloris gayana*, and *Tripsacum laxum* with a focus on improving feed utilization and enhancing milk production among smallholder dairy farmers.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted at Livestock Training Agency (LITA) in Mpwapwa district, located 120 km from Dodoma, the capital city of Tanzania. The district is at latitude 6° 40' 00" S and longitude 36° 25' 00" E, dominated by mountainous topography. The district has a dry savanna climate characterized by a marked seasonal rainfall distribution with a long dry season starting from late April to late November and a short wet season starting late November to the end of April. The average amount of rainfall for the year in Mpwapwa is 712.4 mm. The month with the most rainfall on average is January, with 136.7 mm of precipitation. The month with the least rainfall on average is August, with an average of 1.7 mm. The average temperature for the year in Mpwapwa is 23°C. The warmest month on average is November with an average temperature of 29.7°C. The coolest month on average is July, with an average temperature of 20°C.

2.2. Treatments of Ensiling Material

Three different treatments were administered by mixing the chopped *Chloris gayana*, and *Tripsacum laxum* with additives and then immediately filled into the bags. The treatments were therefore: T1 *Chloris gayana*, or *Tripsacum laxum* grass alone as a control (CONTROL). T2 *Chloris gayana*, or *Tripsacum laxum* grass and 10% Maize bran (MB). T3 *Chloris gayana*, or *Tripsacum laxum* grass and 3% Molasses (MOL).

2.3. The Ensiling Procedures

The ensiling materials were chopped using a bush knife to 2-4cm particles and carefully packed into the plastic bags so as to avoid making any holes in the bags. Strong, high density shopping plastic bags with a capacity to carry 10 kg of chopped *Chloris gayana*, or *Tripsacum laxum* grass was used in this study. Only 4.85kg of ensiling material was carefully packed in each shopping plastic bag. Each bag was gently squeezed by hand to expel air, while compressed; the neck of each bag was twisted then turned over and tied with a rubber band thereafter labelled with treatment identity. Each bag was then inverted into a second empty shopping plastic bag which was also tied and labelled and put in a hessian bag to protect it from rupturing. For each treatment there were two hessian bags each containing three shopping bags filled with ensiling materials. All hessian bag was placed in earth pit 90cm deep x 75 cm wide x 500 cm long under tree shade. The hessian bags were covered by a plastic sheet to protect them from termites and then the pit was re-filled with the soil to form an earth mound over the earth pit so as to clear rain water away from the pit.

2.4. Sampling Procedures

The silages were opened at 21 days after ensiling. Silages showing spoilage spots were insignificant showing that the bags were airtight water proof as much as possible. Two samples each 200g were taken from each ensiling bag. First sample was used to analyse pH, the second used to analyse dry matter DM, ash, crude protein (CP), ether extract (EE), crude fibre (CF), neutral detergent fibre (NDF), acid detergent fibre (ADF), metabolizable energy (ME) and determination of in vitro dry matter digestibility.

2.5. Data Collection

The pH of silages was recorded by using a pH meter. Silage samples were dried and ground to pass through a 1mm sieve, then analyzed. The samples were analyzed for dry matter DM, ash, crude protein (CP), ether extract (EE), crude fibre (CF), neutral detergent fibre (NDF) and acid detergent fibre (ADF) at Tanzania Veterinary Laboratory Agency (TVLA) Central Veterinary Laboratory, Dar es Salaam using a near infrared reflectance (NIR) spectrometer (Perkin Elmer, DA 7250™) calibrated according to the manufacturer's instructions for analysis of forages. Nitrogen Free Extract was calculated from the above obtained chemical composition by the formula NFE% = 100 - (%Moisture +% ash +% CP +% EE +%CF). Metabolizable energy (ME) content was estimated using the equation developed by MAFF [9], that is ME (MJ/kg DM) = 0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE. The equation 0.15 (0.98*DMD - 4.8) was used to determine the Metabolizable energy (ME) content of silage.

In vitro dry matter digestibility (IVDMD) and in vitro organic matter digestibility (IVOMD) of samples determined after grinding samples to a 2 mm size, then determined according to Tilley & Terry [10], two-stage technique. Digestibility was done at the Animal Nutrition Laboratory of the Sokoine University of Agriculture, Department of Animal, Aquaculture, and Range Sciences. The organoleptic test was done using panel score method and average was recorded.

Organoleptic data collected included colour, smell, texture and tase, data were collected by panel and average observation score was recorded.

Table 1. *Criteria for assessing organoleptic Rhodes grass (Chloris gayana) silage.*

Criteria	**Quality score**	
	Descriptive	**Score**
Color		
Dark brown	Bad	1
Green brown	Good	2
Light yellow	Very good	3
Smell		
Vinegar	Bad	1
Pleasant	Good	2
Fruity	Very good	3
Texture		
Moderately firm	Moderate good	1
Firm	Good	2
Taste		
Very acidic	Bad	1
Sharply acidic	Good	2
Not very much sharply acidic	Very good	3
Moderately sharply acidic	Excellent	4

Table 2. *Criteria for assessing organoleptic Guatemala grass (Tripsacum laxum) silage.*

Criteria	**Quality score**	
	Descriptive	**Score**
Color		
Dark brown	Bad	1
Blue green	Good	2
Light yellow	Very good	3
Golden	Excellent	4
Olive green	well	5
Smell		
Offensive (ammonia	Bad	1
Vinegar	Good	2
Tobacco	Very good	3
Pleasant	Excellent	4

Criteria	Quality score	
	Descriptive	Score
Texture		
Slimy	Bad	1
Friable and dry	Good	2
Moderate firm	Very good	3
Taste		
Strong acidic and clinging	Bad	1
Sharp acidic	Good	2
Moderately sharp acidic	Very good	3

2.6. Experimental Design and Statistical Analysis

The data obtained from the experiment were analysed using the General Linear Model (GLM) procedure of SAS (1990). The experiment was arranged in a completely randomized design (CRD) with a factorial arrangement. The treatments consisted of different additives of *Chloris gayana*, or *Tripsacum laxum* grass silage and were replicated across experimental units. Least Square Means were used to compare treatment means, and significant differences among treatments were determined at p = 0.05. Organoleptic data obtained in this study were processed using Microsoft Excel series 2024 Data Analysis. If it had a significant effect, then it was further tested using the Least Significant Difference Test (LSD) method.

The statistical model used was:

$$Yij = \mu + Ti + eij$$

Where:
1) Yij = Observation on the jth replicate of the ith treatment
2) μ = Overall mean common to all observations
3) Ti= Effect of the ith treatment (different silage additives)
4) eij = Random error associated with each observation

3. Results

3.1. Rhoes Grass Silage Chemical Composition

Chemical composition of Rhodes grass (*Chloris gayana)* silage is presented in Table 3. T2 had a significantly ($P < 0.05$) higher CP (6.9%) and EE (3.8%) among treatments, while it was observed that T1 had a significantly ($P < 0.05$) lower CP (5.01%) and EE (2.3%) among treatments. Ash content was observed to be significantly ($P < 0.05$) higher for T1 (13.2%) while lowest percentage was observed for T2 (11.8%). T1 had a significantly ($P < 0.05$) higher fibers NDF and ADF (69.5%) and (44.5%) respectively, while it was observed that T2 had a significantly ($P < 0.05$) lower fibers NDF and ADF (60.5%) and (37.5%) respectively among treatments.

Table 3. *Mean effects of additives on Rhodes grass (Chloris gayana) silage chemical composition.*

Parameters	Additive treatments			P-Value
	T1: No additive	T2: 10% Maize bran	T3: 3% Molasses	
DM%	37.4 ± 0.85^{a}	36.02 ± 0.78^{a}	33.2 ± 0.92^{a}	0.071
ASH%	13.2 ± 0.40^{a}	11.8 ± 0.35^{c}	12.5 ± 0.38^{b}	0.041
CP%	5.01 ± 0.25^{c}	6.9 ± 0.30^{a}	5.7 ± 0.28^{b}	0.018
EE%	2.3 ± 0.12^{c}	3.8 ± 0.15^{a}	2.8 ± 0.14^{b}	0.009
CF%	34.5 ± 1.10^{a}	29.0 ± 0.95^{c}	31.5 ± 1.00^{b}	0.022
NDF%	69.5 ± 1.50^{a}	60.5 ± 1.30^{c}	63.0 ± 1.40^{b}	0.011
ADF%	44.5 ± 1.20^{a}	37.5 ± 1.05^{c}	40.5 ± 1.10^{b}	0.015

Means in the same row within with different superscript letters are significant differences ($P < 0.05$).
DM= Dry matter, CP=Crude protein, EE= Ether extract, CF= Crude Fibre, NDF=Neutral detergent fibre, ADF=Acid detergent fibre

3.2. Guatemala Grass Silage Chemical Composition

Chemical composition of Guatemala grass (*Tripsacum laxum)* silage is presented in Table 4. T2 had a significantly ($P < 0.05$) higher CP (6.2%) and EE (3.5%) among treatments, while it was observed that T1 had a significantly ($P < 0.05$) lower CP (4.6%) and EE (2.1%) among treatments. Ash content was observed to be significantly ($P < 0.05$) higher for T1

(12.8%) while lowest percentage was observed for T2 (11.3%). T1 had a significantly ($P < 0.05$) higher fibres NDF and ADF (72.0%) and (47.0%) respectively, while it was observed that T2 had a significantly ($P < 0.05$) lower fibres NDF and ADF (63.0%) and (40.5%) respectively among treatments.

Table 4. *Mean effects of additives on Guatemala grass (Tripsacum laxum) silage chemical composition.*

Parameters	Additive treatments			P-Value
	T1: No additive	T2: 10% Maize bran	T3: 3% Molasses	
DM%	35.8 ± 0.90^{a}	34.6 ± 0.85^{a}	32.4 ± 0.95^{a}	0.081
ASH%	12.8 ± 0.45^{a}	11.3 ± 0.40^{c}	12.0 ± 0.42^{b}	0.036
CP%	4.6 ± 0.22^{c}	6.2 ± 0.28^{a}	5.3 ± 0.25^{b}	0.021
EE%	2.1 ± 0.10^{c}	3.5 ± 0.14^{a}	2.6 ± 0.12^{b}	0.010
CF%	36.5 ± 1.20^{a}	31.0 ± 1.05^{c}	33.5 ± 1.10^{b}	0.025
NDF%	72.0 ± 1.60^{a}	63.0 ± 1.40^{c}	66.0 ± 1.50^{b}	0.013
ADF%	47.0 ± 1.30^{a}	40.5 ± 1.10^{c}	43.5 ± 1.20^{b}	0.017

Means in the same row within with different superscript letters are significant differences ($P < 0.05$).
DM= Dry matter, CP=Crude protein, EE= Ether extract, CF= Crude Fibre, NDF=Neutral detergent fibre, ADF=Acid detergent fibre

3.3. Invitro Digestibility and Metabolisable Energy of Rhodes and Guatemala Silage

Invitro digestibility and Metabolisable energy percentages of Rhodes and Guatemala silage is presented in Table 5. T2 had a significantly ($P < 0.05$) higher both IVOMD and IVDMD (63.8%) and (61.5%) respectively for Rhodes grass silage among additive treatments. T1 had a significantly ($P < 0.05$) lower both IVOMD and IVDMD (52.5%) and (50.2%) for Rhodes grass silage among additive treatments. Metabolisable energy of Rhodes grass silage was significantly ($P < 0.05$) higher for T2 (9.4 MJ/kg DM) and lowest value was obtained for T1 (7.8 MJ/kg DM). T2 had a significantly ($P < 0.05$) higher both IVOMD and IVDMD (60.5%) and (58.2%) respectively for Guatemala grass silage among additive treatments. T1 had a significantly ($P < 0.05$) lower both IVOMD and IVDMD (49.0%) and (46.8%) for Guatemala grass silage among additive treatments. Metabolisable energy of Guatemala grass silage was significantly ($P < 0.05$) higher for T2 (8.9 MJ/kg DM) and lowest value was obtained for T1 (7.2 MJ/kg DM).

Table 5. *Mean effects of additives on Rhodes grass (Chloris gayana and Guatemala grass (Tripsacum laxum) on invitro digestibility and metabolisable energy.*

Silage	Additive Treatments	Parameters		
		IVOMD (%)	IVDMD (%)	ME (MJ/kg DM)
Rhodes grass (Chloris gayana)	T1: No additive	52.5 ± 1.20^{c}	50.2 ± 1.10^{c}	7.8 ± 0.25^{c}
	T2: 10% Maize bran	63.8 ± 1.35^{a}	61.5 ± 1.25^{a}	9.4 ± 0.30^{a}
	T3: 3% Molasses	58.6 ± 1.30^{b}	56.3 ± 1.20^{b}	8.6 ± 0.28^{b}
	P-Value	0.012*	0.015*	0.010**
Guatemala grass (Tripsacum laxum)	T1: No additive	49.0 ± 1.30^{c}	46.8 ± 1.20^{c}	7.2 ± 0.28^{c}
	T2: 10% Maize bran	60.5 ± 1.40^{a}	58.2 ± 1.30^{a}	8.9 ± 0.32^{a}
	T3: 3% Molasses	55.2 ± 1.35^{b}	53.0 ± 1.25^{b}	8.0 ± 0.30^{b}
	P-Value	0.014*	0.017*	0.011**

Means in the same column within the same parameter on the same treatment and silage with different superscript letters are significant differences (P < 0.05).
IVDMD=Invitro Dry matter digestibility, IVOMD=Invitro Organic matter digestibility, ME=Metabolizable energy

3.4. pH Values of Rhodes and Guatemala Silage

pH values of both silages Rhodes and Guatemala are presented in Table 6. T1 had a significantly (P < 0.05) higher pH values for both Rhodes and Guatemala silage (4.65%) and (4.80%) respectively. T3 was observed to have significantly (P < 0.05) lower pH values for both Rhodes and Guatemala silage (3.95%) and (4.05%) respectively.

Table 6. *Mean effects of additives on Rhodes grass (Chloris gayana) and Guatemala grass (Tripsacum laxum) on pH values.*

Silage	pH value			P-Value
	T1: No additive	T2: 10% Maize bran	T3: 3% Molasses	
Rhodes grass	4.65 ± 0.08[a]	4.25 ± 0.07[b]	3.95 ± 0.06[c]	0.008**
Guatemala grass	4.80 ± 0.09[a]	4.40 ± 0.08[b]	4.05 ± 0.07[c]	0.010**

Means in the same row within with different superscript letters are significant differences (P < 0.05).

3.5. Organoleptic Test of Rhodes and Guatemala Silage

Organoleptic scores for colour, smell, texture and taste for both Rhodes and Guatemala silage are presented in Table 7.

Rhodes silage

Based on analysis of variance in treatments T1, T2, and T3 showed a significant effect (P<0.05) on the color of silage, where T2 scored average of 2.70 indicating almost Light yellow colour which is the best silage fermented colour. T1 had a score of 1.3 dark brown colour indicated poor fermented silage. There was a significant effect (P<0.05) of treatments on silage smell where T2 had average score of 3 which is fruity smell indicating the best silage smell among all treatments, T1 with score 1.7 had a vinegar smell indicating poor fermented among treatments. Taste showed significant effect (P<0.05) among treatments, T1 and T2 having no sharp acidity taste indicating well fermentation.

Guatemala silage

Treatments had significant effect (P<0.05) on silage colour where by T2 with score of 4 of Golden colour indicated well fermented colour while T1 with the score of 2.3 of Brue green colour showing poor fermentation colour. Treatments had significant effect (P<0.05) on silage smell where T2 with the score of 4 having pleasant smell indicating a well fermentation. There was a significant effect (P<0.05) of treatments on silage texture where T1 with firm texture score of 2.3 as the best texture. There was a significant effect (P<0.05) of treatments on silage taste, T3 with the score of 2.3 sharp acidic taste and T1 had strong acidic taste.

Table 7. *The average effect of treatment on colour, smell, texture and and taste.*

Silage	Additive Treatments	Organoleptic Parameter Scores			Taste
		Color	Smell	Texture	
Rhodes grass	T1: No additive	2.00 ± 0.40b	2.00 ± 0.39b	2.00 ± 0.00a	3.30 ± 0.54a
	T2: 10% Maize bran	2.70 ± 0.40a	3.00 ± 0.39a	2.00 ± 0.00a	3.30 ± 0.54a
	T3: 3% Molasses	1.30 ± 0.40c	1.70 ± 0.39c	2.00 ± 0.00a	1.67 ± 0.54b
	P-Value	0.12	0.09	NS	0.04
Guatemala grass	T1: No additive	2.33 ± 0.49c	2.33 ± 0.56b	2.33 ± 0.38a	1.00 ± 0.40b
	T2: 10% Maize bran	4.00 ± 0.49a	4.00 ± 0.56a	1.00 ± 0.38c	2.00 ± 0.40ab

Silage	Additive Treatments	Organoleptic Parameter Scores			
		Color	Smell	Texture	Taste
	T3: 3% Molasses	3.00 ± 0.49b	2.33 ± 0.56b	1.67 ± 0.38b	2.33 ± 0.40a
	P-Value	0.05	0.03	0.18	0.11

Means in the same column within the same parameter on the same treatment and silage with different superscript letters are significant differences ($P < 0.05$).

4. Discussion

This study evaluated the effect of maize bran and molasses additives on silage fermentation of two forage spp *Chloris gayana* and *Tripsacum laxum*. The goal was to address dry season feed shortages by exploring effects of different additives on most available grass forage spp Rhodes (*Chloris gayana)* and Guatemala (*Tripsacum laxum)* as a locally available and affordable forages during rainy season among farmers in Mpwapwa district and similar geographical areas.

4.1. Chemical Composition of Rhodes and Guatemala Silage

Proximate analysis to determine the chemical composition of Rhodes (*Chloris gayana)* and Guatemala (*Tripsacum laxum)* silages was conducted to assess nutritional adequacy, particularly in terms of CP, ME, and fiber fractions such as NDF and ADF, which are key indicators of feed quality for ruminants [11, 12]. The nutritional evaluation aimed to establish whether the silages could meet or exceed the minimum dietary requirements needed to support microbial activity in the rumen and maintain growth and production of ruminants [13, 14].

Rhodes silage

The CP content of Rhodes silages in this study was in align with silage crude protein which is needed for normal rumen bacterial growth and function for ruminants as recommended by Gurung [13]. According to that study, if dietary protein is in deficient forage intake and digestibility are depressed. This means that the silage was capable of providing the nitrogen required by microbes to synthesize volatile fatty acids for microbial protein synthesis [14]. The increase in CP observed in T2 may be attributed to the contribution of nutrients from maize bran and improved fermentation conditions that minimized nutrient losses during ensiling [15]. Similar findings were reported by Lyimo [16] who observed improved nutritive value and silage quality when maize bran was added to tropical grass silages.

The lower fibre fractions (CF, NDF and ADF) observed in T2 indicate improved digestibility and feeding value of the silage. According to Muck [17], reduction in fibre components following additive application has also been reported in king grass and Napier grass silages treated with fermentable carbohydrate additives. These additives stimulate lactic acid bacteria fermentation, leading to better preservation and partial breakdown of structural carbohydrates [18].

The control treatment (T1) exhibited the highest ash, NDF and ADF contents, suggesting poorer fermentation quality and higher concentration of structural components. According to Muck [17], high NDF and ADF values generally reduce feed intake and digestibility in ruminants. The lower CP and EE values in the control treatment may have resulted from nutrient degradation and poor fermentation efficiency due to insufficient fermentable carbohydrates during ensiling [19].

Molasses treatment (T3) showed intermediate values between T1 and T2. Molasses provides readily fermentable sugars that enhance lactic acid production and preservation quality. Previous studies have shown that molasses improves silage fermentation and nutritive value of tropical grasses by increasing microbial fermentation efficiency [20].

The non-significant difference in dry matter (DM) content among treatments indicates that the additives had limited influence on moisture conservation during ensiling. Similar observations were reported in studies involving tropical forage silages treated with carbohydrate additives [20].

Guatemala silage

The higher CP values in T2 could be associated with reduced proteolysis and enhanced microbial activity during ensiling. Tropical grasses are generally characterized by low soluble carbohydrate content, which limits proper fermentation. Addition of maize bran supplies fermentable carbohydrates that promote rapid acidification and preservation of nutrients. Similar improvements in CP and reductions in fibre content have been documented in tropical grass silages treated with maize bran and carbohydrate additives [16].

The control treatment recorded the highest NDF and ADF values, indicating lower digestibility and poorer feeding quality. High fibre contents in untreated tropical grass silages have been associated with advanced plant maturity and inadequate fermentation. According to previous studies, untreated silages commonly experience nutrient losses due to undesirable microbial activity [20].

Molasses treatment (T3) also improved the nutritional quality of Guatemala grass silage compared to the control, although its effect was less pronounced than maize bran. The study by Pirassununga [21], concluded that molasses enhances fermentation by providing water-soluble carbohydrates required by lactic acid bacteria, thereby reducing fibre concentration and preserving nutrients. Similar findings were reported in elephant grass and king grass silages supplemented with molasses [16, 20]. Dry matter content did not differ significantly among treatments, suggesting that additive inclusion mainly influenced nutrient composition rather than moisture content [22].

Comparison between Rhodes Grass and Guatemala Grass Silages

Comparison between the two grass species revealed that Rhodes grass silage generally had slightly better nutritive quality than Guatemala grass silage across all treatments. Rhodes grass recorded higher CP and lower fibre fractions (NDF and ADF) than Guatemala grass. These differences may be related to species variation in cell wall composition, growth characteristics and nutrient accumulation [23].

Guatemala grass showed relatively higher fibre contents, indicating lower digestibility compared to Rhodes grass. Tropical grasses with higher structural carbohydrate contents are usually less digestible and have lower feeding value for ruminants. Similar differences among tropical forage species have been reported in previous silage studies [20].

Both grass species responded positively to additive application, especially maize bran, which consistently improved CP and EE while reducing fibre fractions. This suggests that maize bran is an effective additive for improving the nutritional quality of tropical grass silages. Molasses also improved silage quality but to a lesser extent compared to maize bran [24-26].

Overall, Rhodes grass ensiled with 10% maize bran produced the best nutritional quality among treatments evaluated in the study. The improvement in silage quality observed with additive use confirms the importance of supplying fermentable carbohydrates during ensiling of tropical grasses to enhance nutrient preservation and digestibility.

4.2. Invitro Digestibility and Metabolisable Energy of Rhodes and Guatemala Silage

Rhodes grass silage consistently showed higher digestibility and ME values compared to Guatemala grass silage across all treatments. This difference may be associated with species variation in cell wall composition and fibre concentration [27]. Rhodes grass is generally characterized by lower fibre fractions and higher nutritive quality than many tropical grasses, which contributes to greater digestibility [28]. Previous studies reported that tropical grasses with lower NDF and ADF contents tend to exhibit higher IVDMD and IVOMD values because fibre components negatively affect rumen degradation [28].

The lower digestibility and ME values observed in the control silages may have resulted from poor fermentation due to inadequate fermentable substrates. Insufficient soluble carbohydrates can limit lactic acid bacteria growth, resulting in undesirable fermentation and increased nutrient losses [14]. This reduces the availability of digestible organic matter and consequently lowers metabolizable energy content. Similar observations were reported in grass silage studies where untreated silages had reduced digestibility and feeding value compared with additive-treated silages [29].

Molasses treatment (T3) also improved digestibility and ME compared to the control, although its effects were lower than maize bran treatment. Molasses supplies readily fermentable sugars which stimulate lactic acid production and improve silage preservation [28]. Enhanced fermentation reduces structural carbohydrate concentration and increases digestible nutrients. Studies on tropical grass silages have shown that molasses addition improves fermentation characteristics, digestibility and energy availability in silage [30].

The positive relationship between digestibility and metabolizable energy observed in this study agrees with previous reports indicating that feeds with higher organic matter digestibility generally provide more utilizable energy to ruminants. Increased digestibility enhances nutrient availability for microbial fermentation in the rumen, thereby increasing energy supply for animal production [31].

4.3. pH Values of Rhodes and Guatemala Silage

The study showed that additive treatments had a clear effect on silage fermentation quality, digestibility, and metabolizable energy in both Rhodes grass (*Chloris gayana*) and Guatemala grass (*Tripsacum laxum*).

Across both forages, silage pH was significantly reduced by the application of additives compared to the control treatment. The lowest pH values were observed in the molasses treatment, followed by maize bran, while the control treatment recorded the highest pH. This indicates that the inclusion of fermentable carbohydrate sources enhances lactic acid fermentation, leading to faster acidification and improved silage preservation. Similar findings have been widely reported, where carbohydrate-rich additives improve fermentation quality by promoting lactic acid bacteria activity and reducing pH [32, 33].

Rhodes grass silage generally showed better fermentation characteristics than Guatemala grass silage across all treatments, reflected by lower pH values and improved nutritive quality. This suggests that Rhodes grass is more readily fermentable, likely due to lower fibre content and better availability of soluble carbohydrates [34]. In contrast, Guatemala grass appears to have a higher buffering capacity and fibre concentration, which slows fermentation and delays acid production [35].

4.4. Organoleptic Test of Rhodes and Guatemala Silage

The organoleptic characteristics of silage including colour, smell, texture, and taste are important indicators of fermentation quality and feed acceptability. In the present study, additive treatments significantly influenced most sensory parameters in both Rhodes grass (*Chloris gayana*) and Guatemala grass (*Tripsacum laxum*) silages.

For Rhodes grass silage, maize bran treatment produced better colour and smell scores compared to the control and molasses treatments. The light yellow colour and fruity smell observed in maize bran-treated silage are characteristics commonly associated with good fermentation and adequate lactic acid production [34]. In contrast, the dark brown colour and vinegar smell observed in the control treatment suggest undesirable fermentation and possible nutrient deterioration. Similar observations were reported by Umesh [35, 37], who indicated that well-fermented silage generally possesses a pleasant or fruity smell and light green to yellowish colour, while dark colour and pungent odor indicate poor fermentation. Texture was not significantly affected among treatments, indicating that the additives had limited influence on physical firmness of Rhodes silage the observations similarly reported by Recalde [32]. Taste scores also varied significantly, where treatments with lower acidity were associated with better fermentation quality and feed acceptability similarly to [36].

In Guatemala grass silage, maize bran treatment also resulted in superior colour and smell scores, with golden colour and pleasant smell indicating efficient fermentation. According to Wang [38], the blue-green colour observed in the control treatment suggests incomplete fermentation and poor preservation. Pleasant smell is generally associated with dominance of lactic acid fermentation, while strong acidic odors may indicate excessive acid accumulation or undesirable microbial activity [39]. Texture differed among treatments, with firm texture indicating better compaction and preservation characteristics. Taste scores showed that molasses treatment produced sharper acidic taste compared to the control treatment, likely due to increased lactic acid production from rapid sugar fermentation [40].

Comparison between the two forage species showed that Rhodes grass silage generally had more favorable texture and balanced taste characteristics, while Guatemala grass silage showed superior colour and smell in some treatments, particularly with maize bran addition. These differences may be related to species variation in moisture content, fibre composition, and fermentable carbohydrate availability, which influence microbial fermentation patterns during ensiling [41].

Overall, additive treatments improved the organoleptic quality of both silages compared to the control treatment. Maize bran treatment consistently produced better sensory characteristics, particularly colour and smell, suggesting improved fermentation and preservation quality. Organoleptic evaluation therefore confirms the positive effects of additives on silage quality and supports the chemical and digestibility results observed in the present study.

5. Conclusion

The study demonstrated that the use of additives significantly improved the fermentation quality, chemical composition, digestibility, metabolizable energy, pH, and organoleptic characteristics of both Rhodes grass (*Chloris gayana*) and Guatemala grass (*Tripsacum laxum*) silages. Additive treatments enhanced crude protein and ether extract contents while reducing fibre fractions such as NDF and ADF compared to the control treatment. Improved nutrient composition resulted in higher in vitro dry matter digestibility, in vitro organic matter digestibility, and metabolizable energy values.

Among the additives evaluated, maize bran produced the best overall silage quality by improving nutritive value, digestibility, and sensory characteristics, while molasses was more effective in lowering silage pH and enhancing fermentation. The control treatment consistently showed poorer fermentation quality, higher fibre content, lower digestibility, and inferior organoleptic characteristics, indicating the importance of additives during ensiling of tropical grasses.

Rhodes grass silage generally performed better than Guatemala grass silage across most parameters, suggesting better fermentability and feeding value. However, both forage species responded positively to additive application, confirming their potential as suitable silage materials for dry season feeding under smallholder dairy production systems.

Therefore, the use of maize bran and molasses as silage additives is recommended to improve preservation and nutritive quality of tropical grass silages. Adoption of these low-cost feed conservation technologies can help reduce seasonal feed shortages and improve livestock productivity among smallholder dairy farmers in Tanzania and similar agro-ecological areas.

Future research should evaluate the long-term effects of maize bran and molasses-treated silages on animal performance (milk yield, growth, and feed efficiency), economic profitability, and silage preservation under different agro-ecological conditions and storage durations to support wider adoption by smallholder dairy farmers.

Abbreviations

ADF	Acid Detergent Fibre
ANOVA	Analysis of Variance
CF	Crude Fibre
CP	Crude Protein
CRD	Completely Randomized Design
DM	Dry Matter
EE	Ether Extract
GLM	General Linear Model
IVDMD	In Vitro Dry Matter Digestibility
IVOMD	In Vitro Organic Matter Digestibility
LAB	Lactic Acid Bacteria
LITA	Livestock Training Agency
LSD	Least Significant Difference
MB	Maize Bran
ME	Metabolizable Energy
MOL	Molasses
NDF	Neutral Detergent Fibre

NFE	Nitrogen Free Extract
NIR	Near Infrared Reflectance
SAS	Statistical Analysis System
SUA	Sokoine University of Agriculture
T1	Treatment One (Control)
T2	Treatment Two (10% Maize Bran)
T3	Treatment Three (3% Molasses)
TVLA	Tanzania Veterinary Laboratory Agency

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Author Contributions

Fredrick Thadei Karumuna: Conceptualization, Formal Analysis, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft

Andrew Modest Mihambo: Data curation, Funding acquisition, Resources, Visualization, Writing – review & editing

Conflicts of Interest

The authors declare that they have no conflict of interest.

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