ISRG Journal of Agriculture and Veterinary Sciences (ISRGJAVS)

ISRG PUBLISHERS
Abbreviated Key Title: ISRG. J. Agri.Vet.Sci.
ISSN: 3048-8869 (Online)
Journal homepage: https://isrgpublishers.com/gjavs/
Volume – II Issue -IV (July-August) 2025
Frequency: Bimonthly

Effects of Ensiling with or Without Microbes on Selected Common Rice Straw Varieties from Uganda as Feed for Dairy Cattle

Ondiek, J.O.[1], Kemboi, F.[2]*, Muema, L.[3], Ntinyari, P.N.[4], Mugambi, A.[5], Ajambo, R.[6], Olengo, G.[7], Odongo, S.[8], Shakala, E.K.[9] and Cheng, Y.[10]

[1,4 & 9] Egerton University, Department of Animal Sciences, P.O. Box 536-20115, Egerton, Kenya.

[2*] Kenya Agricultural and Livestock Research Organization, Beef Research Institute, Lanet, P.O. Box 3840- 20100, Nakuru, Kenya.

[3,5 & 7] Kilimo Trust Kenya, P.O. Box 536-20115, Egerton University, Njoro, Egerton, Kenya.

[6 & 8] Kilimo Trust Uganda, Bugolobi, Kampala, Uganda.

[10] Nanjing Agricultural University, Laboratory of Gastrointestinal Microbiology, Nanjing, 210095, Jiangsu, China

| **Received:** 26.06.2025 | **Accepted:** 02.07.2025 | **Published:** 13.07.2025

***Corresponding author:** Kemboi, F.

Kenya Agricultural and Livestock Research Organization, Beef Research Institute, Lanet, P.O. Box 3840- 20100, Nakuru, Kenya.

Abstract

This study evaluated the effects of ensiling selected rice straw varieties with or without microbial additives (molasses, yeast, and a combination of both) on their nutritional composition and the subsequent effects on dairy cattle performance in Uganda. The rice straw varieties included Supa, Nerica 4, and K85, common in lowland and upland cultivation. Crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), dry matter (DM), and metabolizable energy (ME) were assessed through chemical analyses. Ensiling with molasses and yeast significantly improved CP (up to 7.54%), lowered fiber fractions, and increased ME to 8.5 MJ/kg. Feeding trials on lactating dairy cows demonstrated increased feed intake, milk yield, and feed conversion efficiency for treated straw diets compared to untreated controls. Notably, milk composition, particularly fat and protein content, were enhanced with microbially treated straw. The study concludes that ensiling rice straw with microbial additives enhances its nutritive value and can effectively replace more expensive conventional feeds in Uganda's smallholder dairy systems.

Keywords: Dairy Cattle, Ensiling, Feed Conversion Efficiency, Microbial Additives, Milk Yield, Rice Straw

DOI: 10.5281/zenodo.15872352

Introduction

Livestock production, particularly dairy farming, is a vital component of Uganda's agricultural sector. However, low productivity per animal remains a persistent issue, largely attributed to inadequate and poor-quality feed resources, especially during dry seasons. Rice straw, a by-product of rice production, is one of the most abundant agro-residues in Uganda, especially in Eastern and Northern regions. Despite its abundance, rice straw is often underutilized or wasted due to its low nutritive value and high fiber content.

Previous studies have highlighted the potential of rice straw as a basal feed resource for ruminants, provided that its digestibility and protein content can be improved through physical, chemical, or biological treatments (Van Soest, 1994; Wanapat et al., 2009). Ensiling is one such treatment method, offering the advantage of preservation while enhancing palatability and nutrient availability. Molasses and yeast have been commonly used as energy and microbial additives, respectively, in silage preparation to improve fermentation quality and nutritive value (McDonald et al., 1991; Kung et al., 2003).

Rice straw, like other cereal straws, is characterized by high cellulose content, low protein, and poor digestibility, making it a feed of limited nutritional value (Chaji et al., 2010). The high silica content in rice straw further limits its digestibility in ruminants (Van Soest, 2006). However, various treatment methods have been employed to enhance its nutritive value. Biological treatments, including microbial inoculation, have gained attention as environmentally friendly and cost-effective alternatives to chemical treatments (Wanapat et al., 2013).

Ensiling with additives has been shown to improve the nutritional profile of rice straw through the production of organic acids and partial hydrolysis of complex carbohydrates (Weinberg and Muck, 1996). Molasses provides readily fermentable carbohydrates for lactic acid bacteria, promoting rapid pH decline and better preservation (Bolsen et al., 1996). Yeast, particularly *Saccharomyces cerevisiae,* may enhance fiber degradation through the production of enzymes and stimulation of cellulolytic bacteria in the rumen (Newbold et al., 1996; Chaucheyras-Durand et al., 2008).

In Uganda, little is known about the ensiling potential of locally available rice straw varieties and their impact on dairy cow performance. This study, therefore, aims to assess the effects of ensiling rice straw with or without microbial additives- molasses, yeast, or their combination its chemical composition and the subsequent feed intake, milk yield, and milk composition in lactating dairy cattle.

Materials and methods

Study Area

The experiment was conducted in Eastern Uganda, primarily in Tororo, Lower Kween, and Butaleja districts, regions known for their extensive rice cultivation. The climate is typically tropical with bimodal rainfall ranging from 1000 to 1500 mm annually and temperatures between 20°C and 32°C.

Experimental and forage collection site

Rice straw was collected from the major rice-growing zones with smallholder mixed crop-livestock systems in Tororo, Butaleja, and Kween Districts in Uganda as Part of the Reduce-Reuse-Recycle Rice Initiative (R4iCSA-II) project. It involved engaging farmers with cattle already in rice and dairy production with two crop cycles for on-farm testing and data collection.

Experimental Design and Treatments

The study employed a completely randomized design (CRD) involving three commonly grown rice straw varieties: Supa (lowland), Nerica 4 (upland), and K85 (lowland). The varieties were subjected to four treatments: untreated control, ensiling with molasses, ensiling with yeast, and ensiling with a combination of molasses and yeast. Each treatment was replicated three times. Treatment diets included:

T1. Untreated rice straw silage (control)
T2. Rice straw silage with molasses (5% w/w)
T3. Rice straw with yeast (0.5% w/w)
T4. Rice straw with yeast + molasses (0.5% + 5% w/w)

Ensiling Procedure

Freshly harvested rice straw was chopped to 2-4 cm lengths and mixed with 5% molasses, 0.5% yeast (*Saccharomyces cerevisiae*), or both, according to the treatment specifications. Molasses was diluted with water in a 1:4 ratio before application to ensure even distribution throughout the straw. For yeast treatments, commercial baker's yeast was activated in warm water (35°C) for 15 minutes before being sprayed onto the chopped straw. The mixtures were thoroughly mixed by hand and compacted into airtight plastic bags with a capacity of 500 kg. Air was manually excluded before sealing to create anaerobic conditions necessary for proper fermentation. The ensiled materials were stored in a cool, dry place at ambient temperature (23-28°C) and allowed to ferment anaerobically for 21 days. After the ensiling period, samples were taken from each bag for chemical analysis.

Feeding Trial and Animal Management, and Data Collection

Sixteen dairy cows (Holstein-Friesian crossbreds, early lactation stage, 350 ± 25 kg BW, 30-60 days in milk) were used in a completely randomized block design. The cows were blocked based on milk yield and parity, and randomly assigned to one of the four treatment groups (four cows per treatment). The feeding trial lasted 74 days, with the first 14 days used as an adaptation period followed by 60 days of data collection.

The cows were individually housed in well-ventilated stalls with concrete floors and were fed 12 kg DM of the respective rice straw-based diet and 2 kg of concentrate supplement per day. The concentrate contained 18% CP and was composed of maize bran (40%), cottonseed cake (25%), wheat bran (15%), sunflower cake (18%), mineral premix (1%), and common salt (1%). The total feed offered was based on 4% of the animals' body weight. Water and mineral licks were provided *ad libitum*.

Feed was offered twice daily at 8:00 am and 4:00 pm, with the concentrate given during milking. Feed refusals were collected and weighed every morning before fresh feed was offered. Feed intake was calculated as the difference between feed offered and refusals. The cows were milked twice daily at 6:00 am and 5:00 pm, and individual milk yields were recorded at each milking. Milk samples were collected weekly from both morning and evening milking for composition analysis.

Feed Efficiency (FE) was calculated as: **FE = Milk Yield (kg) / Dry Matter Intake (DMI in kg)**

The daily milk yield was calculated as: **Daily Milk Yield (kg) = Morning yield (kg) + Evening yield (kg)**

DOI: 10.5281/zenodo.15872352

The average daily milk yield was calculated as: **Average Milk Yield (kg/day) = Total Milk Yield (kg) / Number of Days.**

Milk composition was analyzed for protein, fat, lactose, and total solids using a LactoScan milk analyzer (Milkotronic Ltd).

Laboratory Analysis

Samples of untreated and treated rice straw were analyzed for dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), and metabolizable energy (ME) using standard procedures (AOAC, 2005; Van Soest et al., 1991).

Dry matter was determined by oven-drying samples at 105°C for 24 hours (AOAC, 2005; method 934.01). Ash content was determined by incineration in a muffle furnace at 550°C for 3 hours (AOAC, 2005; method 942.05). Crude protein was calculated as nitrogen × 6.25, with nitrogen determined using the Kjeldahl method (AOAC, 2005; method 954.01). Ether extract was determined by extraction with petroleum ether (AOAC, 2005; method 920.39). NDF, ADF, and ADL were analyzed according to Van Soest et al. (1991) using the ANKOM fiber analyzer (ANKOM Technology, Macedon, NY, USA). Metabolizable energy was calculated based on the in vitro organic matter digestibility following the equation described by Menke and Steingass (1988).

Statistical Analysis

Data collected on proximate analysis, feed intake, milk yield, and Feed efficiency were subjected to the analysis of variance (ANOVA) in a randomized complete block design (RCBD) using the General Linear Model procedure of Statistical Analysis System (SAS 2002) version 9.0. Significant means were separated using Tukey's HSD (Tukey's Honestly Significant Difference Test) at 5% significance. The linear Model for RCBD used was:

$$Y_ij = u + Ti + \beta j + Eij$$

Yij - any observation for which i is the treatment factor.
j is the blocking factor
µ - the mean
Ti - the effect of being in treatment i
Bj -is the effect of being in a block.
Eij -random error

Results and Discussion

Chemical Composition of Rice Straw Varieties

The chemical composition of the different rice varieties used in the study is presented in Table 1. The dry matter content of the rice straw varieties ranged from 89.6% to 93.4%, with K23 having the highest DM content (93.4%) and Narorice/PR017 having the lowest (89.6%). Ash content varied from 16.45% to 20.63%, with Narorice/PR017 showing the highest ash content. Crude protein content was generally low across all varieties, ranging from 3.30% (Narorice 1) to 4.46% (K23). Ether extract was relatively similar across varieties (1.35-1.77%). Crude fiber ranged from 27.95% (Wita 9) to 34.44% (K85). Metabolizable energy values ranged from 6.4 to 7.1 MJ/kg DM, with K23 and Wita 9 having the highest values (7.1 MJ/kg DM) and Narorice 1 having the lowest (6.4 MJ/kg DM).

Table 1: Chemical composition (g kg^{-1} DM) of Rice varieties used in making silage.

Rice variety	DM %	Ash%	CP %	EE %	CF%	ME (MJ/kg)
Wita 9	89.7	18.538	3.646	1.623	27.954	7.1
K85	90.3	17.507	3.819	1.597	34.440	6.8
Narorice 1	92.1	17.449	3.299	1.773	31.219	6.4
K23	93.4	16.450	4.456	1.348	31.762	7.1
Narorice/ PR017	89.6	20.629	3.877	1.524	32.801	6.7

DM: Dry matter; CP: Crude protein; EE: Ether extract; CF: Crude fiber; ME: Metabolizable energy

Effect of Treatment on Chemical Composition of Rice Straw Silage

The effects of different treatments on the chemical composition of rice straw silage are shown in Table 2. Significant differences (P<0.0001) were observed among treatments for all nutritional parameters. The crude protein content increased significantly with microbial treatment, with T4 (molasses + yeast) exhibiting the highest CP content (7.55%), followed by T3 (yeast only) at 6.42%. The untreated control (T1) had the lowest CP content at 3.43%.

Metabolizable energy was significantly improved by the treatments, with T2 (molasses) and T4 (molasses + yeast) showing the highest values (8.53 and 8.30 MJ/kg, respectively), which were significantly higher (P<0.0001) than T3 (yeast only) at 7.82 MJ/kg and the control (T1) at 6.51 MJ/kg.

The fiber fractions (CF, NDF, ADF, and ADL) decreased significantly with treatment. The NDF content decreased from 72.73% in the control to 54.63% in T4. Similarly, ADF decreased from 46.34% in the control to 35.32% in T4, while ADL declined from 6.79% to 3.31%. The combination of molasses and yeast (T4) resulted in the most significant reduction in fiber fractions.

Table 2: Chemical composition (g kg^{-}1 DM) of experimental diets

Parameters	T1	T2	T3	T4	P value
CP %	3.425^b	5.212^b	6.417^a	7.548^a	<.0001
ME Mj/kg	6.512^c	8.525^a	7.822^b	$8.2\ 97^a$	<.0001
CF %	35.278^a	33.866^b	33.864^b	31.590^c	<.0001
NDF	72.73^a	60.51^b	57.45^c	54.63^d	<.0001
ADF	46.34^a	38.3^b	36.23^c	35.32^c	<.0001
ADL	6.79^a	4.21^b	3.24^c	3.31^c	<.0001

DOI: 10.5281/zenodo.15872352

T1: Untreated rice straw silage (control); T2: Rice straw silage with molasses; T3: Rice straw with yeast; T4: Rice straw with yeast + molasses. [a,b,c,d] Means within a row with different superscripts differ significantly (P<0.05). CP: Crude protein; ME: Metabolizable energy; CF: Crude fiber; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; ADL: Acid detergent lignin.

Effect of Treatment on Feed Intake, Milk Yield, and Feed Efficiency

The effects of the different treatments on dry matter intake, milk yield, and feed efficiency are presented in Table 3. Significant differences (P<0.0001) were observed among treatments for all parameters. Dry matter intake was significantly higher in cows fed T2 (molasses) and T4 (molasses + yeast) (10.15 and 10.13 kg/day, respectively) compared to those fed T3 (yeast only) (9.50 kg/day) and the control T1 (8.17 kg/day). Milk yield varied significantly among treatments, with cows fed T4 producing the highest milk yield (10.82 kg/day), followed by T2 (7.58 kg/day), T3 (5.36 kg/day), and finally the control T1 (3.94 kg/day). Average milk yield followed a similar pattern, with T4 resulting in significantly higher production (10.11 kg/day) compared to other treatments. Feed efficiency, calculated as milk yield divided by dry matter intake, was also significantly affected by the treatments. Cows fed T4 exhibited the highest feed efficiency (1.06), followed by T2 (0.75), T3 (0.58), and T1 (0.48).

Table 3: Dry matter feed intake and milk yield of dairy animals fed on treated rice straw silage.

Parameters	TI	T2	T3	T4	SEM	P
DM intake (Kg/day)	8.165^c	10.153^a	9.501^b	10.134^a	0.0806	<.0001
Milk yield (Kg/day)	3.943^d	7.581^b	5.362^c	10.823^a	0.13754	<.0001
Average Milk Yield (kg/day)	3.881^d	7.551^b	5.475^c	10.113^a	0.12217	<.0001
Feed Efficiency	0.4843^d	0.7476^b	0.5750^c	1.0640^a	0.01450	<.0001

T1: Untreated rice straw silage (control); T2: Rice straw silage with molasses; T3: Rice straw with yeast; T4: Rice straw with yeast + molasses. [a,b,c,d] Means within a row with different superscripts differ significantly (P<0.05). SEM: Standard error of mean.

Effect of Treatment on Milk Composition

The effects of different treatments on milk composition are presented in Table 4. Significant differences (P<0.0001) were observed among treatments for all milk composition parameters. Total solids were highest in milk from cows fed T4 (8.87%), followed by T3 (8.67%), T2 (8.32%), and the control T1 (7.30%). Milk density followed a similar pattern, with T4 resulting in the highest density (31.28), followed by T3 (30.72), T2 (29.63), and T1 (26.08). Protein content was significantly higher in milk from cows fed T3 (3.37%) and T4 (3.35%) compared to T2 (3.12%) and the control T1 (2.68%). Lactose content was highest in milk from cows fed T4 (5.02%), followed by T3 (4.88%), T2 (4.75%), and the control T1 (4.08%).

Table 4: Milk composition of the different experimental treatments

Parameters	TI	T2	T3	T4	*P value*
Solids	7.3000^c	8.3167^b	8.6667^a	8.8667^a	<.0001
Density	26.083^c	29.633^b	30.717^a	31.283^a	<.0001
Protein	2.6833^c	3.1167^b	3.3667^a	3.3500^a	<.0001
Lactose	4.0833^c	4.7500^b	4.8833^b	5.0167^a	<.0001

T1: Untreated rice straw silage (control); T2: Rice straw silage with molasses; T3: Rice straw with yeast; T4: Rice straw with yeast + molasses. [a,b,c] Means within a row with different superscripts differ significantly (P<0.05).

Effect of Milking Time on Milk Composition

The effects of milking time (morning vs. evening) on milk composition are presented in Table 5. No significant differences (P>0.05) were observed between morning and evening milkings for any of the milk composition parameters. Total solids, density, protein, and lactose content were slightly higher in morning milk compared to evening milk, but these differences were not statistically significant.

Table 5: Milk composition during different milking times

	Milking times		
Parameters	**Morning**	**Evening**	**P Value**
Solids	8.660^a	8.380^a	0.2442
Density	30.680^a	29.727^a	0.2442
Protein	3.3133^a	3.160^a	0.0907
Lactose	4.867^a	4.747^a	0.3043

[a] Means within a row with the same superscripts do not differ significantly (P>0.05).

DOI: 10.5281/zenodo.15872352

Discussion

Chemical Composition of Rice Straw Varieties

The chemical composition of the rice straw varieties used in this study (Table 1) is consistent with previous reports on the nutritional profile of rice straw. The low crude protein content (3.30-4.46%) and high fiber fractions observed across all varieties are typical characteristics of rice straw, as reported by Sarnklong et al. (2010) and Chaji et al. (2010). According to Van Soest (2006), the high silica content in rice straw, which was not directly measured in this study but is reflected in the high ash content (16.45-20.63%), contributes significantly to its low digestibility and nutritional value.

The variations in chemical composition among rice straw varieties observed in this study can be attributed to differences in genetic makeup, growing conditions, soil fertility, and harvesting stage (Vadiveloo, 2003; Sarnklong et al., 2010). Interestingly, K23 showed a relatively higher crude protein content (4.46%) compared to other varieties, suggesting potential genetic traits that might be worth exploring for improved straw quality in breeding programs. The relatively high ash content in Narorice/PR017 (20.63%) could indicate high silica content, which may negatively affect digestibility (Van Soest, 2006).

The metabolizable energy values (6.4-7.1 MJ/kg DM) are within the range reported for untreated rice straw (Rahman et al., 2010). However, these values are considerably lower than those of good quality forages, which typically range from 8 to 12 MJ/kg DM (McDonald et al., 2011), highlighting the need for treatment to enhance the nutritional value of rice straw for dairy cattle.

Effect of Treatment on Chemical Composition of Rice Straw Silage

The significant improvements in nutritional composition of rice straw following ensiling with additives (Table 2) demonstrate the effectiveness of these treatments in enhancing feed quality. The increase in crude protein content with microbial treatments, particularly with the combination of molasses and yeast (T4, 7.55%), is notable and can be attributed to several factors. Yeast cells themselves contribute to the nitrogen content, as reported by Wanapat et al. (2009). Additionally, the fermentation process may increase microbial biomass, which contains protein (Elmenofy et al., 2012). The presence of molasses in T2 and T4 provides readily fermentable carbohydrates that could support microbial growth, thereby increasing the microbial protein content of the silage (Bolsen et al., 1996).

The reduction in fiber fractions (NDF, ADF, ADL) following treatment, particularly in T4, is consistent with findings by Elmenofy et al. (2012) and Wanapat et al. (2013). This reduction can be attributed to partial hydrolysis of cell wall components during the ensiling process, facilitated by enzymes from the yeast and other microorganisms present in the silage. Saccharomyces cerevisiae has been reported to produce enzymes that can break down complex carbohydrates (Newbold et al., 1996; Chaucheyras-Durand et al., 2008), which explains the reduction in fiber content in T3 and T4. The lower fiber content in T2 compared to the control can be attributed to the dilution effect of adding molasses and the stimulation of microbial fermentation, which may have led to some hydrolysis of cell wall components (Bolsen et al., 1996).

The increased metabolizable energy values in the treated silages, particularly in T2 (8.53 MJ/kg) and T4 (8.30 MJ/kg), reflect improved fermentation quality and reduced fiber content. Molasses provides readily fermentable sugars that contribute directly to the energy content while also supporting the fermentation process (McDonald et al., 1991). The combination of molasses and yeast in T4 appears to have a synergistic effect, where molasses provides the substrate for fermentation, and yeast enhances the breakdown of complex carbohydrates, resulting in improved energy availability.

Conclusions and Recommendations

This study demonstrates that ensiling rice straw with microbial additives, particularly a combination of molasses and yeast, significantly improves its nutritional value and performance in lactating dairy cows. The key findings include:

1. Ensiling rice straw with molasses and yeast (T4) resulted in significant improvements in nutritional composition, including increased crude protein (7.55%) and metabolizable energy (8.30 MJ/kg), and decreased fiber fractions (NDF 54.63%, ADF 35.32%, ADL 3.31%).
2. Dairy cows fed rice straw silage treated with molasses and yeast (T4) had significantly higher dry matter intake (10.13 kg/day), milk yield (10.82 kg/day), and feed efficiency (1.06) compared to the control and other treatments.
3. Milk composition, including total solids, density, protein, and lactose content, was significantly improved in cows fed treated rice straw silage, particularly with yeast (T3) and a combination of molasses and yeast (T4).
4. The combination of molasses and yeast (T4) had a synergistic effect, leading to the best overall results in terms of silage quality, dairy cow performance, and milk composition.

These findings suggest that ensiling rice straw with microbial additives, particularly a combination of molasses (5%) and yeast (0.5%), is an effective strategy for improving its nutritive value and can be recommended for smallholder dairy farmers in Uganda. This approach offers a sustainable solution for utilizing rice straw, an abundant agricultural by-product, as a valuable feed resource for dairy cattle, potentially reducing feed costs and improving dairy productivity in the region.

Further research is recommended to investigate the long-term effects of feeding treated rice straw silage on dairy cow health and reproductive performance, as well as the economic feasibility of this approach in different farming systems in Uganda.

Acknowledgements

Kilimo Trust (KT) for financial support. We acknowledge technical support from the Animal Sciences Department at Egerton University, on questionnaire administration, farmer training, feeding trial set up, and laboratory analysis.

Author contribution

The study's inception and design were contributions from all the writers. James Ondiek, Kemboi Fred, and Purity Nthiyari prepared the material, collected the data, and conducted the analysis. Laboratory analyses for feeds and milk were done by Shakala. The first draft of the article was written by James Ondiek, and it was read and approved by the other authors.

Funding

It was extremely appreciated that the Kilimo trust provided funding through the rice livestock integration project.

DOI: 10.5281/zenodo.15872352

Conflict
The authors have no competing interests and agree to publish the manuscript.

Effect of Treatment on Feed Intake, Milk Yield, and Feed Efficiency
The significantly higher dry matter intake observed in cows fed treated rice straw silage, particularly T2 and T4 (Table 3), can be attributed to improved palatability and digestibility. Molasses is known to enhance palatability (McDonald et al., 1991; Bolsen et al., 1996), which explains the higher intake in T2 and T4. The reduced fiber fractions and increased energy content in these treatments likely contributed to faster rumen clearance rates, allowing for higher feed intake (Allen, 2000). Similar improvements in dry matter intake following treatment of rice straw have been reported by Wanapat et al. (2009) and Rahman et al. (2010).

The substantial increase in milk yield with treated rice straw silage, particularly T4 (10.82 kg/day compared to 3.94 kg/day for the control), demonstrates the significant impact of improved feed quality on dairy cow performance. The higher milk yield can be attributed to increased nutrient availability, particularly energy and protein, as reflected in the improved chemical composition of the treated silages (Table 2). The combination of molasses and yeast in T4 appears to have a synergistic effect, providing both readily available energy from molasses and enhanced fiber digestion from yeast activity, leading to higher milk production.

The improved feed efficiency observed in cows fed treated silage, particularly T4 (1.06), indicates better utilization of nutrients for milk production. This is consistent with the findings of Wanapat et al. (2009) and Elmenofy et al. (2012), who reported improved feed conversion efficiency in ruminants fed treated rice straw. The higher feed efficiency in T4 followed by T2 suggests that the inclusion of molasses plays a crucial role in enhancing nutrient utilization, possibly by providing readily fermentable carbohydrates that improve rumen function (Bolsen et al., 1996; Kung et al., 2003).

Effect of Treatment on Milk Composition
The significant improvements in milk composition with treated silage (Table 4) further demonstrate the nutritional benefits of the treatments. The higher total solids, density, protein, and lactose content in milk from cows fed treated silage, particularly T3 and T4, can be attributed to improved nutrient availability and balance. The higher protein content in milk from cows fed T3 and T4 (3.37% and 3.35%, respectively, compared to 2.68% for the control) reflects the higher crude protein content of these diets (Table 2).

The higher lactose content in milk from cows fed T4 (5.02% compared to 4.08% for the control) can be attributed to improved energy availability, as lactose synthesis is primarily dependent on glucose availability (Sutton, 1989). The improved energy status of cows fed T4, as indicated by the higher ME content of this diet (Table 2), likely supported higher lactose synthesis.

The lack of significant differences in milk composition between morning and evening milkings (Table 5) is consistent with the findings of Quist et al. (2008), who reported minimal diurnal variations in milk composition under consistent feeding and management conditions. This suggests that the observed improvements in milk composition with treated silage are consistent throughout the day and not subject to significant diurnal variations.

References

1. **Allen, M.S. (2000).** Effects of diet on short-term regulation of feed intake by lactating dairy cattle. *Journal of Dairy Science*, 83(7), 1598-1624.
2. **AOAC. (2005).** Official Methods of Analysis. 18th Edition, Association of Official Analytical Chemists, Gaithersburg, MD, USA.
3. **Bolsen, K.K., Ashbell, G., & Weinberg, Z.G. (1996).** Silage fermentation and silage additives - Review. *Asian-Australasian Journal of Animal Sciences*, 9(5), 483-493.
4. **Chaji, M., Mohammadabadi, T., & Mamouei, M. (2010).** Chemical composition and digestibility of rice straw treated with microwave and sodium hydroxide. *Journal of Animal and Veterinary Advances*, 9(21), 2729-2732.
5. **Chaucheyras-Durand, F., Walker, N.D., & Bach, A. (2008).** Effects of active dry yeasts on the rumen microbial ecosystem: Past, present and future. *Animal Feed Science and Technology*, 145(1-4), 5-26.
6. **Elmenofy, E.K., Elsayed, I., Abbas, H.M., Darwish, M.S., & Moustafa, K.M. (2012).** Impact of treating rice straw with urea or fungus on chemical composition, *in vitro* digestibilities and rumen fermentation. *Journal of Agricultural Science*, 4(10), 196-204.
7. **Kung, L., Stokes, M.R., & Lin, C.J. (2003).** Silage additives. In D.R. Buxton, R.E. Muck, & J.H. Harrison (Eds.), Silage Science and Technology (pp. 305-360). American Society of Agronomy, Crop Science Society of America, Soil Science Society of America.
8. **McDonald, P., Edwards, R.A., Greenhalgh, J.F.D., Morgan, C.A., Sinclair, L.A., & Wilkinson, R.G. (2011)**. Animal Nutrition (7th ed.). Pearson Education Limited, Harlow, UK.
9. McDonald, P., Henderson, A.R., & Heron, S.J.E. (1991). The Biochemistry of Silage (2nd ed.). Chalcombe Publications, Marlow, UK.
10. **Menke, K.H., & Steingass, H. (1988).** Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. *Animal Research and Development*, 28, 7-55.
11. **Newbold, C.J., Wallace, R.J., & McIntosh, F.M. (1996).** Mode of action of the yeast Saccharomyces cerevisiae as a feed additive for ruminants. *British Journal of Nutrition*, 76(2), 249-261.
12. **Quist, M.A., LeBlanc, S.J., Hand, K.J., Lazenby, D., Miglior, F., & Kelton, D.F. (2008).** Milking-to-milking variability for milk yield, fat and protein percentage, and somatic cell count. *Journal of Dairy Science*, 91(9), 3412-3423.
13. **Rahman, M.M., Akbar, M.A., Islam, K.M.S., Khaleduzzaman, A.B.M., & Bostami, A.B.M.R. (2010)**. Nutrient digestibility and growth rate of bull calves fed rice straw treated with wood ash extract. *Bangladesh Journal of Animal Science*, 39(1-2), 97-105.
14. **SAS. (2002)**. Statistical Analysis System. SAS/STAT User's Guide, Version 9.0. SAS Institute Inc., Cary, NC, USA.
15. **Sarnklong, C., Cone, J.W., Pellikaan, W., & Hendriks, W.H. (2010).** Utilization of rice straw and

DOI: 10.5281/zenodo.15872352

different treatments to improve its feed value for ruminants: A review. *Asian-Australasian Journal of Animal Sciences*, 23(5), 680-692.

16. **Sutton, J.D. (1989).** Altering milk composition by feeding. *Journal of Dairy Science*, 72(10), 2801-2814.
17. **Vadiveloo, J. (2003).** The effect of agronomic improvement and urea treatment on the nutritional value of Malaysian rice straw varieties. *Animal Feed Science and Technology*, 108(1-4), 133-146.
18. **Van Soest, P.J. (1994).** Nutritional Ecology of the Ruminant (2nd ed.). Cornell University Press, Ithaca, NY, USA.
19. **Van Soest, P.J. (2006).** Rice straw, the role of silica and treatments to improve quality. *Animal Feed Science and Technology*, 130(3-4), 137-171.
20. **Van Soest, P.J., Robertson, J.B., & Lewis, B.A. (1991).** Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, 74(10), 3583-3597.
21. **Wanapat, M., Kang, S., Hankla, N., & Phesatcha, K. (2013).** Effect of rice straw treatment on feed intake, rumen fermentation and milk production in lactating dairy cows. *African Journal of Agricultural Research,* 8(17), 1677-1687.
22. **Wanapat, M., Polyorach, S., Boonnop, K., Mapato, C., & Cherdthong, A. (2009).** Effects of treating rice straw with urea or urea and calcium hydroxide upon intake, digestibility, rumen fermentation and milk yield of dairy cows. *Livestock Science*, 125(2-3), 238-243.
23. **Weinberg, Z.G., & Muck, R.E. (1996).** New trends and opportunities in the development and use of inoculants for silage. *FEMS Microbiology Reviews*, 19(1), 53-68.

DOI: 10.5281/zenodo.15872352