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Feed Utilization and Growth Performance of Tanzania Shorthorn Zebu Fed Untreated or Urea Treated Rice Straws as Hay Replacement in Traditional Feedlot System

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Abstract: This study evaluated the effects of complete or partial replacement of *Cenchrus ciliaris* hay with untreated or urea treated rice straws on feed intake, growth performance, feed conversion ratio (FCR) and gross margin of Tanzania Shorthorn Zebu (TSHZ) cattle under feedlot condition. A total of 50 bulls with age of 2.5 - 3.0 years and mean initial weight of 132.4 ± 26.7 kg were assigned randomly to five treatments *i.e.* 100% *Cenchrus ciliaris* hay (CCH), 100% untreated rice straws (URS), 100% urea treated rice straws (TRS), 50% untreated rice straw + 50% *C. ciliaris* hay (URH) and 50% treated rice straw + 50% *C. ciliaris* (TRH). All animals were supplemented with a diet comprised of 53% maize bran, 25% molasses, 20% sunflower seed cake, 1.5% mineral premix and 0.5% table salt. The results show that average daily gain and weight gain did not differ ($p > 0.05$) among the treatments. However, animals on TRH showed the highest growth rate (770.0 ± 0.1 g/day) and weight gain (64.7 ± 4.4 kg), followed by those on TRS (growth rate = 725.0 ± 0.1 g/day, weight gain = 60.9 ± 4.4 kg) while those on URS had the lowest growth rate (599.0 ± 0.1 g/day) and weight gain (50.3 ± 4.4 kg). Animals fed TRS (9.8 ± 0.1) and TRH (8.9 ± 0.1) had lower ($p \leq 0.001$) FCR than those fed CCH (10.3 ± 0.1), URS (11.9 ± 0.1) and URH (10.4 ± 0.1). The highest gross margin was obtained on animals under TRS (TZS 154,293.00) while the lowest was found on animals under CCH (TZS 120,450.00). Partial or complete replacement of hay with treated or untreated rice straws resulted into higher growth performance than feeding hay alone. Feeding animals with urea treated rice straws resulted into higher growth performance and better feed utilization compared to feeding hay or untreated rice straws. It is concluded that complete replacement of hay with urea treated rice straws resulted into high growth rate, lower FCR and high gross margin, hence, it is recommended as the best basal diet for fattening of TSHZ under traditional feedlot system.

Keywords: Crop Residues, Cattle Fattening, Feed Conversion Ratio, Gross Margin, Growth Rate

1. Introduction

Tanzania has 35.3 million cattle, of which 96.5% are indigenous breeds that produce 98% of beef and 67.7% of milk in the country [1, 2]. Tanzania Shorthorn Zebu (TSHZ) is the predominant indigenous breeds and constitutes about 95% of cattle kept in the country. The breed is kept in semi-arid areas under pastoralism (14%) and agro-pastoralism (80%) production systems due to their good drought, heat and disease tolerance [3, 4]. These agro-pastoralists and pastoralists practice extensive production systems, whereby TSHZ are herded continuously on natural pastures available on communal grazing lands throughout the year. Cattle production under these systems is faced with challenge of inadequate quantity and unavailability of quality feeds, especially during the dry periods. The native grass species, upon which cattle depend, have low nutritional values characterised by low protein and energy contents, and poor digestibility [5, 6].

Therefore, TSHZ reared on these natural pastures have very low beef production with mature weight of 200 - 350 kg, carcass weight of 100 - 175 kg and attain slaughter weight after 5 - 7 years [2]. The slow growth and small mature body size increase greenhouse gases emission per unit of livestock product and affect farmers' livelihoods [7-9]. This, in turn, leads to deficit in red meat supply and failure to meet the increased demand as the result of economic and population growth in Tanzania. According to Michael et al. [10], Tanzania had red-meat deficit of 17% (~125,000 tonnes) in the year 2022. This deficit necessitates a need for efficient cattle production system so as to meet high red-meat demand, improve farmers' livelihoods and protect environment.

Feedlot finish feeding is commonly used as the means to enable mature cattle to attain acceptable market weight within a short time and improve meat quality before slaughter. Cattle under feedlot system are fed nutrient dense diets for a period of up to 90 days under zero grazing system to enable fast weight gain [11-14]. In addition to concentrates, animals under feedlot are given roughage (hay) as basal diet which serves as the source of structural material for proper rumen functioning [14, 15]. However, in recent years hay has become expensive and availability of quality hay is limited by low level of pasture production [16, 17]. Therefore, there is a need to look for cheaper alternative roughage that can be fed as basal diet during feedlot finish feeding. Cereal crop residues such as rice straws can be used as an alternative to hay due to their abundance and easy accessibility [18]. Rice straws have low production cost among cereal crop residues, thus, they can serve as a practical source of fodder for ruminants. However, rice straw can barely support cattle nutritional requirements for maintenance because of their poor digestibility and lower protein content [19, 20].

Urea treatment can improve rice straws digestibility and thus, increase their intake and consequently cattle production performance [21, 22]. In addition, urea treatment increases nitrogen content of the treated straws and this nitrogen can be converted into protein by rumen microbes [23, 24]. There are limited studies on the use of urea treated rice straws as basal diet for TSHZ cattle under feedlot system. Most studies focused on the use of hay or maize stovers as basal diet for cattle under feedlot or substitution of maize meal and molasses with maize bran and rice polishing [12, 20, 21]. Therefore, this study was conducted to evaluate the effects of complete or partial replacement of *Cenchrus ciliaris* hay with untreated or urea-treated rice straws on intake, *in vitro* digestibility, growth performance and profitability of TSHZ finished under traditional feedlot system. It was hypothesized that replacing *C. ciliaris* hay with treated rice straws would result to similar or higher TSHZ growth performance at a reduced cost.

2. Materials and Methods

2.1. Location of the Study Area

Feeding trial was conducted at Mtanana village which is found in Kongwa district (6°- 6°6'S, 26°22'-36°30'E), about 82 km from Dodoma city in central Tanzania. The district has altitude of 1067 m above sea level with annual rainfall of 254 - 660 mm and average daily temperature of 23 - 32°C [25]. Kongwa district has semi-arid climate and open grassland vegetation dominated by *Cynodon* spp, *Aristida* spp., *Chloris gayana* and *Urochloa mosambicensis* grass species [11]. Livestock production is the major economic activity in the district and it is characterised by continuous herding in the communal grazing lands. This warranted selection of the study area for the current feeding experiment.

2.2. Experimental Animals

A total of fifty TSHZ bulls were obtained from the livestock farmers and used in the feedlot experiment. The bulls had the age of 2.5 - 3 years (age was estimated based on dentition) and mean weight of 132.4 ± 26.7 kg (mean ± SD). All animals were dewormed by administering 15 - 20 ml of Albendazole 10% W/V (Bimeda-Oral suspension) according to live weight at the beginning of the study and deworming was repeated after 45 days during the experimental period. External parasites were also controlled by using Albadip Super 100EC (Alphacypermethrin 100%) whereby 1 ml was mixed with 2 litres of water and sprayed on the animal using knapsack sprayer. The experimental animals were assigned randomly to five dietary treatments, with 10 animals per treatment.

2.3. Experimental Feed Preparation

Five dietary treatments were formulated, treatment one consisted of 100% *C. ciliaris* hay (CCH). Treatment two, three, four and five were made up of 100% untreated rice straw (URS), 100% treated rice straw (TRS), 50% untreated rice straw + 50% *C. ciliaris* hay (URH) and 50% treated rice straw + 50% *C. ciliaris* hay (TRH), respectively. Hay used in this study was purchased at Tanzania Livestock Research Institute - Mpwapwa. The hay was cut as standing hay after *C. ciliaris* seed harvesting. Rice straws were collected from Msowero, Kilosa district where SARO 5 (TXD 306) rice variety is cultivated in the lowlands [26]. Some rice straws were treated with 3% urea which was prepared by dissolving 3 kg of urea into 20 litres of water that was used to treat 100 kg of rice straw. Treatment of rice straws was done by spraying the straw with urea solution using knapsack sprayer. The straws sprayed with urea solution were ensiled into a ground silo covered by airproof polythene sheet and allowed to ferment for 21 days. Straws and hay were chopped manually into small pieces of ~3 cm before being fed to the animals. The TRH and URH diets were made by mixing equal weight of hay and treated or untreated rice straws in the trough during feeding.

2.4. Experimental Animal Management and Feeding

The animals were housed in a barn which had five pens with each pen having a size of 20 m x 20 m and a group of 10 animals was allocated into each pen. The treatments were randomly allocated to the five groups of animals, a total of 10 animals per treatment. The treatment for each group formed the basal diet. The experimental animals were given their respective dietary treatment *ad-libitum* early in the morning at 0600 h. The experimental animals were also given concentrate diet as supplementary feed. They were fed concentrate diet at 80% of their daily feed intake (estimated as 3% of their live weight). The concentrate was given into two equal portions at 0800 h and 1400 h. The amount of concentrate diet given daily was determined from the mean live weight of the animals in the respective group. The concentrate diet used in this experiment was formulated to contain 12.7 MJ ME/kg DM and 12 g/kg DM CP. These metabolisable energy (ME) and crude protein (CP) are required for maintenance and daily weight gain of about 1 kg for small sized cattle breeds (~200 kg) as recommended by NRC [27]. The concentrate diet consisted of 53% maize bran, 25% molasses, 20% sunflower seed cakes, 1.5% mineral premix and 0.5% table salt. These ingredients were purchased from the local agro-processing mills and agro-veterinary store at Kibaigwa town, Kongwa district and were mixed thoroughly before were given to the animals. Samples of concentrate diets, individual ingredients and dietary treatments were taken for laboratory chemical analysis to determine the proximate composition. All animals had free access to clean drinking water during the experimental period.

2.4.1. Determination of Feed Intake, Feed Conversion Ratio and Growth Performance

The experimental period was 84 days after the adaptation period of 10 days. The adaptation period aimed at acclimatizing the animals to their respective dietary treatments. The experimental animals were weighed individually before the start of the experiment using a weighing scale and then assigned randomly to the five dietary treatments. Each animal was weighed individually after every 14 days during the experimental period so as to determine average daily gain. Weight gain per animal was calculated as final live weight minus the initial live weight in kg. Average daily gain (ADG) per animal was calculated as weight gain in kg divided by experimental period in days.

The animals were zero grazed and fed their respective dietary treatment in group of 10 bulls per treatment. The amounts of basal diet (hay and rice straws) and concentrate provided to each group were measured before feeding on each day and the feed refusals were collected daily in the morning (prior to next feeding) and weighed so as to determine feed intake for each group. The intake recorded for each group was divided by the number of animals in the group in order to estimate individual animal feed (in dry-matter, DM) intake and metabolisable energy intake (MEI). In addition, feed conversion ratio (FCR) was computed as the ratio of feed intake to weight gained per animal during the study period.

2.4.2. Chemical Analysis of Feed Ingredients and Formulated Diets

Concentrate diet, feed ingredients and dietary treatment samples were analysed for their chemical composition and digestibility at the Animal nutrition laboratory of Sokoine University of Agriculture. The DM, ash, crude protein (CP), ether extract (EE) and crude fibre (CF) were determined according to the standard methods of Association of Official Analytical Chemists [28]. Nitrogen free extract was calculated by subtracting ash, CP, EE and CF from the DM of feed. Van Soest [29] method was used to determine neutral detergent fiber (NDF) and acid detergent fiber (ADF). *In vitro* dry matter digestibility (IVDMD) was analyzed according to Tilley and Terry [30] two-stage procedure. The equation 0.012CP + 0.031EE + 0.005CF + 0.014NFE was used to calculate ME of the concentrates. The ME in hay and rice straws (dietary treatments) was calculated using the equation; 0.15 (0.98*IVDMD-4.8) [31, 32].

2.4.3. Gross Margin Analysis

Gross margin analysis was used to assess the profitability of cattle fattening under different dietary treatments. Gross margin was computed as the difference between total revenue earned and total variable cost incurred. Bull selling was the only revenue source in this study and the value of each bull was calculated as final live weight of an animal multiplied by wholesale price of 1 kg of live weight. Variable cost included costs of purchasing bulls, feeds, and payment for veterinary services and labour. Bulls purchasing price was obtained by multiplying the initial weight of each animal by price of 1 kg of live weight basing on a prevailing market price of such animals at the start of the experiment. Feed cost was calculated by multiplying the total amount of feed consumed by each animal and the market price of one kilogram of feed during the study period. Also, the cost per kg live weight gain was calculated based on FCR and retail price per kilogram of the respective feed. Veterinary services included all the costs incurred during deworming and control of external parasites while labour cost included monthly salary paid to animal attendants. The labour cost was divided by the number of animals to obtain cost per animal.

2.5. Statistical Analysis

Statistical program R (version 4.0.1) was used to analyse data on DMI, MEI, weight gain, growth rate, FCR, feed cost, total variable cost, revenue and gross margin. One-way ANOVA model under completely randomized design was applied during data analysis. The model was defined as Y (feed intake, growth performance, revenue, variable cost and gross margins) = Dietary treatment + Residual error. Tukey's test was used to determine the differences between a pair of treatment means and was declared significant at $p \leq 0.05$.

3. Results

3.1. Chemical Composition of Feed Ingredients and Formulated Diets

The results in Table 1 show that the ME and IVDMD values of *C. ciliaris* hay were lower than those of both untreated and urea treated rice straws. On the other hand, urea treated rice straws had slightly higher ME and IVDMD than untreated rice straws. The NDF and ADF values were relatively higher in *C. ciliaris* hay and untreated rice straws than in urea treated rice straws. Urea treated rice straws had relatively higher CP than untreated ones and *C. ciliaris* hay. Among the feedstuffs used in the experiment, sunflower seed cake had the highest CP (223.7 g/kg DM) and EE (140.3 g/kg DM) while the untreated rice straws (54.2 g/kg DM) and *C. ciliaris* hay (56.9 g/kg DM) had the lowest CP contents. Furthermore, *C. ciliaris* hay had the highest NDF (743.5 g/kg DM) and lowest IVDMD (31.6%) among the feedstuffs used in the experiment.

Table 1. *Chemical composition of feed ingredients and concentrate diet.*

Feedstuff	DM (g/kg)	Ash (g/kg DM)	CP (g/kg DM)	EE (g/kg DM)	NDF (g/kg DM)	ADF (g/kg DM)	IVDMD (%)	ME MJ/kg DM
Concentrate diet	815.1	82.0	112.4	94.9	314.1	131.1	55.6	12.7
Sunflower seed cake	954.6	49.5	233.7	140.3	564.7	393.9	-	-
Maize bran	805.9	46.6	103.5	73.6	497.8	72.6	59.6	13.2
Cenchrus ciliaris hay	855.0	103.9	56.9	-	743.5	413.4	31.6	5.5
Untreated rice straw	872.8	216.0	54.2	-	651.0	405.0	51.9	9.0
Urea treated rice straw	860.5	268.3	72.6	-	543.9	321.8	53.1	9.3

DM = dry matter; CP = crude protein; EE = Ether extract; NDF = neutral detergent fiber; ADF = acid detergent fiber; IVDMD = *In-vitro* dry matter digestibility; ME = metabolisable energy

3.2. Feed Intake, Feed Conversion Ratio and Growth Performance

The dry matter feed intake, ME intake, weight gain, daily weight gains and FCR are shown in Table 2. There were statistical differences ($p < 0.001$) in feed and ME intake among dietary treatments. Animals on URH had higher concentrate intake (5.9 kg DM/day) and total feed intake (7.4 kg DM/day) than the animals on CCH (5.1 kg DM/day for concentrate and 6.4 kg DM/day for total feed). Animals on CCH had the lowest roughage intake (1.3 kg DM/day) while those on TRS had the highest (1.6 kg DM/day). Similarly, total ME intakes were lowest in CCH and highest in TRS.

Table 2. *Feed intake and growth performance (mean ± SE) of Tanzania Shorthorn Zebu cattle subjected to five different dietary treatments.*

Parameters	Dietary treatment					
	CCH	URS	TRS	URH	TRH	p-value
Feed intake (kg DM/day)						
Concentrate	5.1 ± 0.02^a	5.6 ± 0.02^b	5.6 ± 0.02^b	5.9 ± 0.02^c	5.5 ± 0.02^d	<0.001
Roughage	1.3 ± 0.02^a	1.5 ± 0.02^b	1.6 ± 0.02^c	1.5 ± 0.02^b	1.4 ± 0.02^d	<0.001
Total	6.4 ± 0.02^a	7.1 ± 0.02^b	7.1 ± 0.02^b	7.4 ± 0.02^c	6.8 ± 0.02^d	<0.001
Metabolisable energy intake (MJ/day)						
Concentrate	64.8 ± 0.6^a	71.1 ± 0.6^b	71.1 ± 0.6^{b,d}	74.9 ± 0.6^c	69.9 ± 0.6^d	<0.001
Roughage	7.2 ± 0.2^a	13.5 ± 0.2^b	14.9 ± 0.2^b	10.9 ± 0.2^c	10.4 ± 0.2^d	<0.001
Total	72.0 ± 0.7^a	84.6 ± 0.7^b	86.0 ± 0.7^b	85.8 ± 0.7^b	80.3 ± 0.7^c	<0.001
Growth performance						
Initial live weight (kg)	123.6 ± 8.0	146.9 ± 8.0	128.8 ± 8.0	143.8 ± 8.5	120.1 ± 8.0	0.085
Final live weight (kg)	175.4 ± 6.4^c	197.2 ± 6.4^{a,b}	197.3 ± 6.7^{a,b}	203.9 ± 6.7^a	184.8 ± 6.4^{b,c}	0.025
Weight gain (kg)	51.8 ± 4.4	50.3 ± 4.4	60.9 ± 4.4	60.1 ± 4.7	64.7 ± 4.4	0.116
Average daily gain (g/day)	617.0 ± 0.1	599.0 ± 0.1	725.0 ± 0.1	716.0 ± 0.1	770.0 ± 0.1	0.116
Feed Conversion Ratio (FCR)	10.3 ± 0.1^b	11.9 ± 0.1^a	9.8 ± 0.1^c	10.4 ± 0.1^b	8.9 ± 0.1^d	<0.001

Means in the same row with different superscript letters are significant different ($P \le 0.05$)
CCH = Cenchrus ciliaris hay, URS = 100% untreated rice straw, TRS = 100% treated rice straw, URH = 50% untreated rice straw + 50% Cenchrus ciliaris hay, TRH = 50% treated rice straw + 50% Cenchrus ciliaris hay

Growth performance results showed that, there were no statistical differences ($p > 0.05$) in initial live weight, weight gained and average daily weight gain of animals subjected to different dietary treatments. However, treatment had significant effect on final body weight and FCR. Final live weight was highest in animals under URH (203.9 ± 6.7 kg) and lowest in animals under CCH (175.4 ± 6.4 kg). On the other hand, FCR was highest in URS and lowest in TRH.

3.3. Gross Margin Analysis

Results on gross margin analysis are shown in Table 3 whereby the revenue obtained did not differ among dietary treatments ($p = 0.08$). However, it was lower in CCH by TZS 91,164/= compared to URH which had the highest revenue. Total variable cost differed ($p = 0.01$) among the treatments and was 15% higher in URH compared to CCH which had the lowest. The highest cost (TZS 253,109/=) for concentrates was found in URH whereas CCH treatment had the least concentrate cost (TZS 221,470/=). On the other hand, roughage cost was highest in TRS (TZS 35,272/=) and lowest in URS (TZS 22,562/=). The costs of producing 1 kg of live weight comparison showed that it costed more to produce mentioned live weight for the animals fed URS compared to those on TRH. Gross margin did not differ (p =

0.88) among dietary treatments. However, animals on TRS had relatively higher gross return (32.3%) compared to the animals on other treatments.

Table 3. *Economic analysis (in Tanzanian Shillings, TZS) of Zebu cattle subjected to various dietary treatments under traditional feedlot system.*

Parameters	Dietary treatment					
	CCH	URS	TRS	URH	TRH	p-value
Revenue per animal						
Bulls selling price	561,280 ± 21,608	631,040 ± 21,608	631,467 ± 21,608	652,444 ± 22,777	591,360 ± 21,608	0.08
Variable cost per animal						
Bulls purchasing price	170,000 ± 13,417	203,000 ± 13,417	184,000 ± 13,417	206,666 ± 14,143	182,000 ± 13,417	0.30
Concentrate cost	$221,470^{d}$	$242,563^{b}$	$242,563^{b}$	$253,109^{a}$	$235,532^{c}$	<0.001
Roughage cost	$34,020^{b}$	$22,562^{e}$	$35,272^{a}$	$30,559^{d}$	$32,995^{c}$	<0.001
Veterinary cost	3,340	3,340	3,340	3,340	3,340	-
Labour cost	120,000	120,000	120,000	120,000	120,000	-
Total variable cost	$440,830 \pm 13,417^{c}$	$483,465 \pm 13,417^{a,b}$	$477,174 \pm 13,417^{a,b}$	$505,674 \pm 14,143^{a}$	$465,867 \pm 13,417^{b,c}$	0.01
Cost per kg weight gain	7,594	8,293	5,912	5,978	5,244	-
Gross margin	120,450 ± 13,122	147,575 ± 13,122	154,293 ± 13,122	146,770 ± 13,122	125,493 ± 13,122	0.87
Percentage profit margin	27.3	30.5	32.3	29.0	26.9	-

1 USD ≈ TZS 2,356

$^{a, b, c}$ Means in the same row with different letters are statistically different (p<0.05)

CCH = 100% Cenchrus ciliaris hay; URS = 100% untreated rice straw; TRS = 100% treated rice straw; URH = 50% untreated rice straw + 50% Cenchrus ciliaris hay; TRH = 50% treated rice straw + 50% Cenchrus ciliaris hay

4. Discussion

4.1. Chemical Composition of Formulated Diets

The CCH had ME content which was lower than 7.3 - 9.2 MJ ME/kg DM obtained in *C. ciliaris* hay from other studies [31, 32], probably due to differences in growth stage at harvesting. Similarly, *C. ciliaris* had ME lower than untreated and treated rice straw in this study which is contrary to Wei *et al.* [33]. The differences in ME content between *C. ciliaris* and rice straw based diets are due to their variations in IVDMD which was lower than 51 - 68% for *C. ciliaris* based diets [32, 34]. The ME values for untreated and treated rice straws in this study are higher than 6.4 - 8.5 MJ/kg DM obtained by Nazli et al. in rice straw based diets [20]. The ME differences in rice straws could be due to the differences of level of inclusion in the diet and rice variety used. Urea treated rice straws had slightly higher CP and ME contents, and digestibility value compared to untreated rice straws in the present study. This observation is in agreement with the findings by Wanapat et al. [21]. It has been shown that treatment of poor quality forage with urea breaks structural carbohydrate, which enhances digestibility and this, in return, increases forage nutritional values including CP and ME contents [22].

The NDF values were higher in CCH than in URS contrary to the findings obtained by Wei *et al.* [33] who observed lower NDF in corn silage compared to straw based diets. The variation may be because the *C. ciliaris* hay used in this study was harvested at advanced growth stage *i.e.* post seed harvesting. Also, rice straws used in this study belonged to SARO 5 (TXD 306) variety which is a lowland rice and its NDF value in this study is closer to 655 - 676 g/kg DM reported in other lowland rice varieties [34]. Nonetheless, CCH had NDF content within the values of 725 - 898 g/kg DM reported for *C. ciliaris* in other studies [35-37]. The NDF contents affect not only feed intake, but also growth performance of the experimental animals.

4.2. Feed Intake and Growth Performance

The animals on CCH had relatively lower total feed intake compared to those on other dietary treatments due to lower intake of both roughage and concentrate. The *C. ciliaris* hay contributed to lower intake in this study because of its low digestibility as a results of higher NDF content which increases satiety in the animals [38, 39]. Additionally, CCH poor taste could have affected feed intake and palatability in TSHZ as it has been observed before in horses due to extended storage time [40, 41]. Moreover, low total feed intake observed in animals on TRH compared to URH is attributed to additive effects of including *C. ciliaris* hay in treated rice straw. Also, it seems that inclusion of *C. ciliaris* lowered roughage ME intake in URH and TRH treatments compared to URS and TRS which had only untreated rice straws and urea treated rice straws, respectively. This is due to the fact that CCH had low digestibility and poor palatability due to high NDF content as described above.

Experimental animals in this study had total MEI which is in line with the amount of energy required (72.1 MJ/day) for 1 kg daily weight gain in cattle [27]. The total ME intake observed in the present study are closer or within the range of 69.4 - 86.4 MJ ME/day values reported for TSHZ cattle in other studies [11, 12]. It can, therefore, be said that energy levels in the dietary treatments were sufficient to meet TSHZ nutrient requirement for growth. This indicates that any of the dietary treatments could support fast growth of fattened cattle under the traditional feedlot system. However, animals in the present study did not achieve 1 kg daily gain in any of the dietary treatment, despite being supplied with the required energy. This could be due to low genetic potential of the animals for growth or advanced animal age and nutritional background of the animals used in this study.

Moreover, NRC [27] estimation for growth rate is based on European cattle breeds which have larger body size and grow faster than the TSHZ.

Nonetheless, growth rates of cattle under TRS, URH, and TRH treatments were closer to 1 kg/day which showed suitability of these diets for feedlot finishing of TSHZ. Also, animals on CCH had lower weight gain than those on TRS, URH and TRH, mainly due to low CP content and digestibility of *C. ciliaris* hay which resulted into lower roughage and concentrate intakes of animals under CCH. This shows that urea treated rice straws can replace *C. ciliaris* hay in feedlot finish feeding of TSHZ and this can result into even better growth performance. The superior weight gain observed in URH fed animals over those on CCH and URS or TRH over TRS indicate synergistic effects of co-feeding hay and rice straw on enhancing efficiency of rumen ecosystem. This is likely because of an increase in rumen fibrolytic bacteria at the expense of fungal predatory species [42, 43].

The results in this study have shown that complete or partial replacement of *C. ciliaris* hay with treated rice straws led to higher body weight gain and growth rate due to better FCR. The FCR values for animals on treatments in which hay was partially replaced by treated rice straw were slightly lower than those with hay, untreated rice straw or combination of the two. Higher FCR values are indicative of production inefficiencies that may lead to increased contribution of livestock to greenhouse gas emissions and farm economic losses [8, 9]. In this study partial replacement of hay with rice straws increased feed utilization efficiency. On the other hand, urea treatment of rice straws resulted into increased weight gain, growth rate and lower FCR values due to the higher ME intakes. The FCR values for TSHZ observed in this study are within the range of 8.1 - 11.5 reported by Asimwe *et al*. [11], but higher than the FCR of 6.1 - 8.0 reported by Asimwe *et al*. [25] and Kimirei *et al*. [44]. The differences could be due to the differences in plane of nutrition, number of days in the feedlot and physiological condition of fattened bulls. The choice of fattening diet should be substantiated by not only its influence on growth performance but also the economic return.

4.3. Gross Margin Analysis

The three types of rice straw-based treatments (URS, TRS and URH) had higher total variable cost than CCH. This can be attributed to higher roughage and concentrates intake of animals subjected to these treatments, which, in turn, led to higher feed cost in the former. Also, it was observed that URS and URH had lower roughage cost compared to CCH, TRS and TRH. This is because of high price of hay while additional treatment of rice straws with urea increased the cost [17, 23]. Although, there were no significant differences in gross margin among the treatments, animals on TRS showed relatively higher gross margin value compared to those on the other treatments. This is due to relatively fast growth and high weight gain of animals under TRS compared to those on CCH and URS, indicating that treatment of rice straw with urea improved growth performance of the animals and, hence, profit. Although animals on TRH had the highest growth rate and weight gain, the inclusion of hay which has high cost resulted into low profit. Moreover, the percentage profit margin in URS, TRS, URH and TRH were higher or similar to that of CCH. This indicates that replacing hay with rice straws resulted into almost similar profit as it was also noted by Asimwe *et al.* [11] and Njie and Reed [18].

Economically, it costed more to produce 1 kg of live weight in animals under CCH and URS compared to TRS, URH or TRH. This indicates that feeding sole untreated rice straw to fatten TSHZ is uneconomical and inefficient over a long term. Furthermore, the cost per 1 kg gain among all dietary treatments in this study were higher than the cost of TZS 2,374-3,244 obtained by Kimirei et al. [44], but the costs for TRS, URH and TRH are within the value of TZS 3,590 - 6,800 reported by Asimwe et al. [45]. These variations in feed cost can be attributed to differences in dietary feed materials and dry matter intake, inclusion level of ingredients, cost per kilogram of feed and growth rate of experimental animals. Nonetheless, this study has shown that feeding treated rice straws alone or in combination with hay reduced feed cost per kilo gained. Moreover, TRS was found to be better since it resulted into higher gross margin compared to TRH, despite the fact that animals on TRH had higher weight gain and almost similar feed cost per kg gain.

5. Conclusions

It is concluded that complete replacement of *C. ciliaris* hay with urea treated rice straws results into higher growth performance, gross margin and low cost per 1 kg weight gain, but complete replacement of hay with untreated rice straw increases FCR and cost per kg gain under feedlot conditions. Moreover, urea treatment of rice straws resulted into increased nutritive value, higher growth performance and better (lower) FCR than both untreated rice straws and hay. Feeding animals with urea treated rice straws alone or in combinations with 50% hay promotes fast growth, higher weight gains and lower feed requirement per weight gain. The TRS is, therefore, recommended for feeding TSHZ under traditional feedlot system as it results into higher profit than TRH and URS.

Conflict of Interest Statement

The authors declare that they have no competing interests.

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