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PERFORMANCE INDICATORS OF SHEEP FED RICE STRAW SUPPLEMENTED WITH BROWSE LEAVES

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ABSTRACT

The use of browse leaves as a protein source can help ruminants cope with adverse nutritional stress under unpredictable climatic conditions. The objective of this study was to determine feed intake, digestibility, metabolisable energy intake, weight gain and feed conversion efficiency of sheep fed untreated rice straw supplemented with browse leaves. Four forest type rams with an average weight of 27.75± 0.89 kg (2 years old) and in a replicated 4 x 4 Latin square design were used in the digestibility study. Twelve ram lambs of average weight 13.2 kg ± 0.05 kg were assigned to the experimental diets randomly for 12 weeks in the growth study in a completely randomized design. Animals were fed four diets namely: Untreated rice straw (URS) + *Albizzia lebbek* (AL) (Control), URS + *Moringa oleifera* (MO), URS + *Ficus exasperata* (FE) and URS + *Spondias mombin* (SM). The dietary treatment influenced ($p<0.05$) the digestible organic matter in dry matter (DOMD), maintenance energy requirement (MEm), metabolisable energy intake (MEI) and ratio of metabolisable energy intake to maintenance energy requirement (MEI: MEm). The DOMD, MEm, MEI and MEI: MEm were in the range of 965-983 g/kgDM, 3.61-5.36 MJ/d, 9.51-15.8 MJ/d and 2.63-3.38 respectively. The total intake of browse and straw ranged from 428.71 to 487.14 g/d. The average daily gain ranged from 7.14 to 20.24 g/d. The animals fed URS+FE recorded the highest average daily gain ($p<0.05$) while the animals fed URS+AL recorded the lowest average daily gain ($p<0.05$). Feed conversion efficiency ranged from 25.97 to 71.45 kg feed/ kg gain. The sheep fed URS+FE were the most efficient ($p<0.05$) and those fed URS+AL, the least efficient ($p<0.05$). Supplementation of browse leaves to sheep using untreated rice straw as a basal diet improved digestibility with moderate weight gains. These browse leaves (AL, FE, MO and SM) can be used to supplement poor quality ruminant diets for improved performance particularly during periods of feed scarcity.

Key words: Digestible organic matter in dry matter, metabolisable energy, weight gain

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INTRODUCTION

Dry matter (DM), crude protein (CP) and crude fibre of grazed browse leaves and grasses are mainly influenced by precipitation and season [1]. Early period of dry season that comes after raining season usually provides nutritious feed as compared to late dry season [1]. This necessitates the need to provide grazing animals with supplementary feed in order to attain satisfactory level of production especially during periods of scarcity of feed or when feed quality is poor. Browse species are abundant and they maintain a high nutritive value irrespective of the season and therefore may be used as feed throughout the year [2, 3]. Browse leaves have high protein content, minerals and vitamins and are therefore ideal for supplementing low quality cereal crop residues. The usage of browse leaves as protein source may help ruminants to cope with adverse nutritional conditions posed by drivers of climate change [5].
The effect of supplementation with browse is shown by increased survivability and productivity of livestock. For example, a study showed that supplementation of a grass and cassava peels based- diet mixed with *Leucaena leucocephala* or *Gliricidia sepium* resulted in significant growth rate of lambs and their survival to twenty-four weeks [6]. Enhanced nutrition appears to be a more important factor in improving small ruminant production. Rangelands offer the most affordable source of nutrients for ruminants. However, in most parts of the year, rangelands in the tropics do not supply adequate nutrients to ruminants for efficient production. There was a report that, providing supplement to grazing animals improves weight gain [7]. It has been reported that supplemented rice straw with urea-molasses block resulted in improvement in weight gain of sheep [8]. Also, browse leaves have been used as supplements in Ghana resulting in improved intake, digestibility and weight gain of sheep [4, 9, 10, 11].

During the dry season, feed for ruminants is scarce or of poor quality and therefore ruminants lose weight and some even die. Maturity age for ruminants is prolonged because animals lose weight during the dry season. Supplementation of untreated rice straw with browse leaves can help ruminants to continue to maintain or gain weight during the dry season and hence enable them to attain market or maturity weight within a reasonably short period. The objective of this study therefore, was to determine the digestibility, metabolisable energy intake and performance indices of sheep fed untreated rice straw supplemented with browse leaves.

MATERIALS AND METHODS

Location

The study was carried out at the Livestock and Poultry Research Centre (LIPREC), University of Ghana, Legon (5˚ 68'N, 0˚10'W). The pattern of rainfall is bimodal with the major rains in June while the minor is in September-October. The average annual rainfall is 881 mm [12]. Maximum and minimum temperature varies between 24.30 ºC and 32.90 ºC [3, 13].

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Preparation of rice straw

Rice straw obtained from Ashaiman Small Scale Irrigation Project, in the Greater Accra region of Ghana, was chopped into approximately 3 cm pieces using a forage cutter (CeCoCo forage SFC1400, Central Commercial Company, Osaka Japan).

Chemical composition of experimental feeds or diets

Dry matter, Crude Protein and Ash were determined using the methods of Association of Official Analytical Chemist [14]. Fibre components were evaluated by Goering and Van Soest [15].

Digestibility study

Animals and management

Four forest type (Djallonke) rams with an average weight of 27.75±0.89 kg (2 years old) were used. The animals were drenched with albendazole (Oral suspension 10%; Hebei New Century Pharmaceutical Company Limited, China) and sprayed with cypermetrin (12% pour on; Hebei New Century Pharmaceutical Company Limited, China) to control endoparasites and ectoparasites respectively before commencement of the study. The animals were housed in individual metabolism crates (Length = 1.6 m, width = 1 m and height = 1.3 m).

Feeds and feeding

Four diets were assigned to the four forest type (Djallonke) rams in a replicated 4 x 4 Latin square design. The diets fed were: Untreated rice straw (URS) + *Albizzia lebbek* (AL), URS+ *Moringa oleifera* (MO), URS+ *Ficus exasperata* (FE) and URS+ *Spondias mombin* (SM). There was a 14-day feed adjustment period. Animals on untreated rice straw supplemented with browses were fed 200 g of browse from 8:00 hours to 9:00 hours followed by untreated rice straw which was fed *ad libitum*. Water was provided on *ad libitum* basis. Feed intake was measured daily and refusals were collected and bulked for two weeks. Faecal outputs were collected using faecal bags fitted around the anal area and daily faecal outputs were weighed. The animals were weighed before imposing the treatment and on the last day of data collection.

Chemical analysis and calculation of digestible organic matter in dry matter, metabolisable energy intake and maintenance energy requirement

Feeds, refusals (left-overs) and faecal samples were analysed for DM by drying in an oven at 55ºC to a constant weight. Organic matter was determined as DM less the residual ash obtained after ashing at 550ºC for six hours. Organic matter (OM) in the feed and faeces, Dry Matter Intake (DMI) and Digestible Organic Matter in Dry Matter (DOMD) were determined by estimation using an equation below. The values obtained were fitted to an equation according to Ministry of Agriculture, Food and Fishery (MAFF) to calculate Metabolisable Energy Intake (MEI) and then the ratio of MEI to Maintenance Energy Requirement (MEm) for each diet [16].

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DOMD = 100(OM Intake - faecal OM)/OM intake
MEI = DOMD x 0.15 x DMI [16]
MEm = 1.2 + 0.13 (Body weight in Kg) [16]

Where: DOMD is Digestible Organic Matter in Dry Matter; OM: Organic Matter; MEI: Metabolisable Energy Intake; DMI: Dry Matter Intake; MEm: Maintenance Energy Requirement.

Growth performance study

Animals, management and diets

Twelve forest type (Djallonke) ram lambs of average weight 13.2 kg ± 0.05 kg (6 months old) were used to determine weight gains. The animals were housed in individual pens of size 2 m x 1.5 m, which had concrete floors, asbestos roofing and the sides made of wooden rails. Before commencement of the experiment, the animals were sprayed to control ectoparasites with cypermetrin (12% pour on; Hebei New Century Pharmaceutical Company Limited, China) and drenched with Albendazole (Oral suspension 10%; Hebei New Century Pharmaceutical Company Limited, China) to control endoparasites. The twelve ram lambs were placed into four groups of three animals per group. One group was assigned to each of the experimental diets randomly for 12 weeks to evaluate the effect of diets on growth rate and feed conversion efficiency. Feeding adjustment period was two weeks. Live weights were measured every two weeks after a twelve- hour starvation period. Animals were fed four diets namely: Untreated rice straw (URS) + *Albizzia lebbek* (Control), URS + *Moringa oleifera*, URS + *Ficus exasperata* and URS + *Spondias mombin.* The four most preferred browse species from an earlier study were selected as supplements for the growth study [17]. Supplementation of *Albizzia lebbek* was used as control because it was the most preferred browse species out of the eight reported [7]. Feed was placed in wooden feed boxes. Animals were fed 100 g of browse from 8:00 hours to 9:00 hours followed by untreated rice straw which was fed *ad libitum*. Water and mineral lick (Selena Nutricio Animal Block, Spain) were provided *ad libitum* to all animals during the study. Table 1 shows composition of the mineral lick. Browse leaves were harvested from matured trees in the natural rangelands within Coastal Savannah Zone of Ghana.

Experimental design and statistical analysis

The chemical composition and growth data were analysed as completely randomised design based on the model below:

$$Y_{ij} = \mu + T_i + E_{ij}$$

Where:

Yij: the response variable such as DM, ash, CP, Acid Detergent Fibre (ADF), Neutral Detergent Fibre (NDF), Lignin, Initial weight, Final weight, DMI, Feed Conversion Efficiency (FCE) and Average Daily Gain (ADG);
μ: the overall mean;

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Ti: Treatments or Experimental diets: Untreated rice straw (URS) + *Albizzia lebbek* (AL), URS + *Moringa oleifera* (MO), URS + *Ficus exasperata* (FE) and URS + *Spondias mombin* (SM);
Eij: the residual error.

Data obtained from the digestibility study was analysed as a repeated 4 x 4 Latin square design according to the model below:

$$Yijk = \mu + \alpha_i + \beta_j + \Upsilon_k + e_{ijk}$$

Where:

Yijk: response variable such as Digestible Organic Matter in Dry Matter (DOMD), Metabolisable Energy Intake (MEI), Maintenance Energy Requirement (MEm) and the ratio of Metabolisable Energy Intake to Maintenance Energy Requirement (MEI: MEm);
μ: overall mean;
α_i: treatments or Experimental diets: Untreated rice straw (URS) + *Albizzia lebbek* (AL) (Control), URS + *Moringa oleifera* (MO), URS + *Ficus exasperata* (FE) and URS + *Spondias mombin* (SM);
β_j: row;
Υ_k: column;
e_{ijk}: residual error.

All data were subjected to analysis of variance (ANOVA) using GenStat version 12.1 [18]. Significant means were separated using Least Significant Difference.

RESULTS AND DISCUSSION

Chemical composition of experimental diets

The chemical composition of the experimental diets is presented in Table 2. The Dry Matter, Crude Protein, Ash, Neutral Detergent Fibre, Acid Detergent Fibre and lignin values ranged from 402.2 to 900 g/kg, 60.4 to 314 g/kg DM, 90 to 235 g/kg DM, 355 to 620 g/kg DM, 213 to 548 g/kg DM and 68.7 to 187 g/kg DM respectively. In general, the chemical composition recorded was similar to values reported in the same study area [3]. The crude protein values of the browse leaves obtained in this study were within the required range for maintenance and growth of ruminants [19].

Digestible organic matter in dry matter, maintenance energy requirement and metabolisable energy intake

The digestible organic matter in dry matter (DOMD) and metabolisable energy intake (MEI), maintenance energy requirement (MEm) and the ratio of metabolisable energy intake to maintenance energy requirement results are presented in Table 3. The digestible organic matter in dry matter ranged from 965 g/kg DM to 983 g/kg DM. The animals fed untreated rice straw and *Spondias mombin* had the lowest ($p<0.05$) DOMD whiles the highest ($p<0.05$) was recorded in animals fed untreated rice straw and *Albizzia lebbek* (Table 3). The maintenance energy requirement values were from 3.61 to 5.36 MJ/d with animals on untreated rice straw and *Spondias mombin* having the lowest ($p<0.05$) and animals on untreated rice straw and *Albizzia lebbek*, the highest

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(p<0.05) MEm value (Table 3). The metabolisable energy intake ranges from 9.51 to 15.8 MJ/ d. However, the animals on untreated rice straw supplemented with *Spondias mombin* had the lowest (p<0.05) metabolisable energy intake. The ratio of metabolisable energy intake to maintenance energy requirement ranged from 2.63 to 3.38 with animals on untreated rice straw supplemented with *Albizzia lebbek*, *Ficus exasperata* and *Spondias mombin* recording the lowest (p<0.05) ratio of metabolisable energy intake to maintenance energy requirement and animals on untreated rice straw and *Moringa oleifera* recording the highest (p<0.05) ratio of metabolisable energy intake to maintenance energy requirement (Table 3).

The improvement in digestible organic matter in dry matter of sheep due to supplementation has been reported earlier and this has been confirmed by this study [8]. The digestible organic matter in dry matter values obtained (474.7-983 g/kg DM) were similar to the values of 545.2-819.7g/kg DM and 410-820 g/kg DM reported when sheep were fed sodium hydroxide treated rice straw supplemented with browse leaves and when sheep were fed browse leaves solely respectively [20, 21]. The metabolisable energy intake values (2.88 -15.83 MJ/d) obtained in this current study falls within the values of 4.24-5.38 MJ/d reported [20]. However, the values of ratio of metabolisable energy intake to maintenance requirement recorded in this study were higher than an earlier report [20]. It has been proposed that for research purposes the most useful indicator of feed to meet maintenance requirement is the use of the ratio of metabolisable energy intake to maintenance energy requirement [16]. If the ratio is greater than one, then the feed is adequate for maintenance. The values obtained in this study showed that all the diets had ratios greater than one. Therefore, browse supplementation could provide the entire maintenance energy requirement and improve growth performance.

Intake, weight gain and feed conversion efficiency of sheep fed untreated rice straw supplemented with four browse leaves

Browse dry matter intake ranged from 66.00 to 92.42 g/d with sheep fed untreated rice straw supplemented with *Spondias mombin* having the lowest value (p<0.05) and those fed untreated rice straw supplemented with *Albizzia lebbek* having the highest (p<0.05) (Table 4). Straw dry matter intake ranged from 336.29 to 396.72 g/d with sheep fed rice straw supplemented with *Albizzia lebbek* recording the lowest (p<0.05) straw dry matter intake and those fed untreated rice straw supplemented with *Moringa oleifera* having the highest (p<0.05) straw dry matter intake (Table 4). Total intake of browse and straw ranged from 428.71 to 487.14 g/d with sheep offered untreated rice straw supplemented with *Moringa oleifera* having the highest (p<0.05) total intake of browse and straw and those offered untreated rice straw supplemented with *Albizzia lebbek* having the lowest (p<0.05) total intake of browse and straw (Table 4).

The trends of weight gain of sheep fed untreated rice straw supplemented with four different species of browse leaves for 12 weeks are shown in Figure 1. In Figure 1, from the beginning of the feeding till the 8^{th} week, weight gains were almost the same as shown by the standard error bars. From the 9^{th} week, sheep fed untreated rice straw supplemented with *Albizzia lebbek* (AL) had the lowest weight gain, those fed untreated rice straw supplemented with *Moringa oleifera* (MO) and *Spondias mombin*

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(SM) were intermediate and those offered untreated rice straw supplemented with *Ficus exasperata* (FE) had the highest weight gains. Average daily gains were from 7.14 to 20.24 g/d, the sheep fed untreated rice straw and *Ficus exasperata* supplementation recorded the highest ($p<0.05$) and those fed untreated rice straw supplemented with *Albizzia lebbek* recorded the lowest ($p<0.05$) (Table 4). Feed conversion efficiency ranged from 25.97 to 71.45 kg feed/ kg gain. The sheep fed untreated rice straw supplemented with *Ficus exasperata* were the most efficient ($p<0.05$) while those on untreated rice straw and *Albizzia lebbek* supplementation, the least efficient ($p<0.05$) (Table 4).

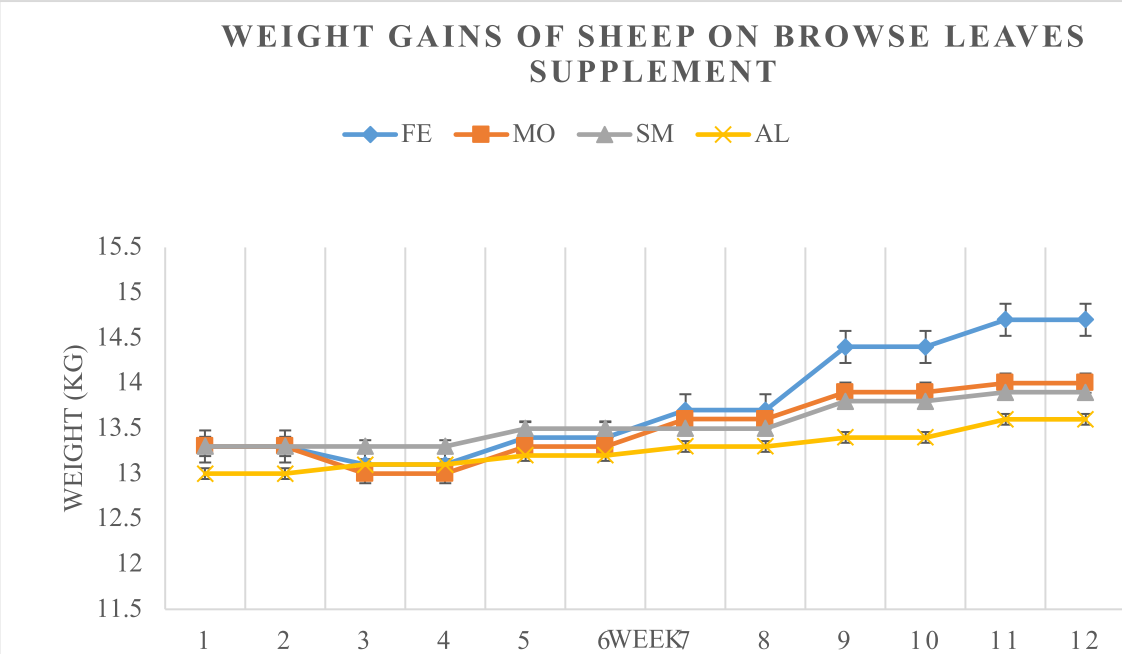

Figure 1: Weight gain of sheep fed untreated straw supplemented with browse leaves

The values of total intake obtained (428.71- 487.14 g/d) in this study were similar to the values of 382.60 - 474.78 g/d and 383.2 - 442.2 g/d reported respectively in Ghana [9, 22]. However, a study in Ghana, reported higher straw and total intakes than the result obtained in this current study and this may be due to the fact that the researchers used lambs that had higher initial weight (17 kg) than the ones used in the current study (13.2 kg) [11]. Also, browse intake was less than 100 g/d in this current study whilst in an earlier report, it was more than 100 g/d [11]. Browse intake varied in this current study even though all the sheep were offered the same quantity of browse leaves. A study noted that variations in browse intake was influenced by factors such as species, plant fractions, stage of maturity, chemical composition and the form (fresh, wilted or dry) in which it is presented [23].

The values of average daily gain (7.14 - 20.24 g/d) recorded in this study were lower than that reported in another study (44.05 - 61.91 g/d) in Ghana [9]. This may be due to the fact that, the researchers fed sodium hydroxide treated rice straw supplemented with some browse leaves which probably enhanced feed intake [9]. Sodium hydroxide treatment improves digestibility and therefore, enhance intake. However, the values of average daily gain obtained in this study falls within the values of 8.28 - 14.85 g/d reported when cassava peels were supplemented with *Ficus exasperata* [22]. The average daily gain recorded in the present study (7.14 - 20.24 g/d) was similar to a study whereby sheep were fed *Albizzia gummifera* (a browse leaves) with or without polyethylene glycol [24]. The values of feed conversion efficiency (25.97-71.45 kg feed/kg gain) recorded in this current study falls within the values (28.68 - 45.93) reported [22].

CONCLUSION

Supplementing untreated rice straw with the browse leaves improved feed intake, digestibility and growth of sheep. The results showed that browse leaves supplementation can help improve the performance of ruminants during the dry season when feed is scarce or of poor quality. It is recommended that *Albizzia lebbek*, *Ficus exasperata*, *Moringa oleifera* and *Spondias mombin* be planted by farmers to serve as live fences and boundary plants so that they can be harvested and fed to ruminants before they are released for grazing.

Ethical clearance

The use of animals was approved by Noguchi Institutional Animal Care and Use Committee of University of Ghana, Legon (Protocol number 2017-02-2R).

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Table 1: Composition of mineral lick used in the study

Components	Proportion
Sodium	38 %
Calcium	1 %
Magnesium	0.50 %
Zinc	290 mg/kg
Manganese	180 mg/kg
Iodine	40 mg/kg
Iron	40 mg/kg
Cobalt	28 mg/kg
Selenium	6 mg/kg

Table 2: Chemical composition (g/kg DM) of experimental diets

Browse species	Chemical components (g/kg DM)					
	DM	CP	Ash	NDF	ADF	Lignin
Albizzia lebbek	580^{c}	289^{d}	90.0^{a}	507^{d}	348^{b}	154^{c}
Ficus exasperata	702^{d}	159^{b}	235^{d}	464^{c}	413^{d}	68.7^{a}
Moringa oleifera	402^{a}	314^{e}	175^{c}	355^{a}	213^{a}	115^{b}
Spondias mombin	432^{b}	166^{c}	103^{b}	443^{b}	358^{c}	169^{d}
Untreated Rice Straw	900^{e}	60.4^{a}	173^{c}	620^{e}	548^{e}	187^{e}
SEM	3.09	1.74	1.64	4.44	2.08	2.27
Probability	<.001	<.001	<.001	<.001	<.001	<.001

Means in the same column having superscripts in common are not significantly different (p>0.05)

DM: Dry Matter; CP: Crude Protein; NDF: Neutral Detergent Fibre; ADF: Acid detergent Fibre

SEM: Standard Error of Means

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Table 3: Digestible organic matter in dry matter, Maintenance Energy Requirement and metabolisable energy intake by sheep fed untreated rice straw supplemented with browse leaves.

Diets	DOMD(g/kg DM)	MEm(MJ/d)	MEI(MJ/d)	MEI:MEm
URS+ *Albizzia lebbek*	983[d]	5.36[d]	15.2[c]	2.84[a]
URS+ *Moringa oleifera*	978[c]	4.68[b]	15.8[c]	3.38[b]
URS+ *Ficus exasperata*	974[b]	4.78[c]	12.6[b]	2.63[a]
URS+ *Spondias mombin*	965[a]	3.61[a]	9.51[a]	2.63[a]
SEM	4.36	0.379	2.52	0.356
Probability values	<.001	<.001	<.001	<.001

Means in the same column having superscripts in common are not significantly different (p>0.05)

DOMD: Digestible Organic Matter in Dry Matter; MEm: Maintenance Energy Requirement; MEI: Metabolisable Energy Intake; MEI: MEm: The ratio of Metabolisable Energy Intake to Maintenance Energy Requirement; URS: Untreated Rice Straw; SEM: Standard Error of Means

Table 4: Intake, weight gain and feed conversion efficiency of sheep fed untreated rice straw supplemented with four browse leaves

Diets	Mean Dry Matter Intake (g /d)			Initial Weight (kg)	Final Weight (kg)	Average Daily Gain (g/d)	FCE (kg feed /kg gain)
	Browse	Straw	Total				
URS+*Ficus exasperata*	76.9[b]	364[b]	441[b]	13.3	15.0	20.2[c]	26.0[a]
URS+*Moringa oleifera*	90.4[c]	397[d]	487[d]	13.3	14.3	11.9[b]	48.7[b]
URS+*Spondias mombin*	66.0[a]	386[c]	452[c]	13.3	14.0	8.33[a]	64.6[c]
URS+*Albizzia lebbek*	92.4[d]	336[a]	429[a]	13.0	13.6	7.14[a]	71.5[d]
SEM	2.19	1.92	2.97	0.935	1.20	1.13	2.14
Prob.	<.001	<.001	<.001	0.408	0.864	<.001	<.001

Means in the same column having superscripts in common are not significantly different (p>0.05)

FCE: Feed Conversion Efficiency; SEM: Standard Error of Means; Prob.: Probability values

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