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Palatability of the Feeds Developed from *Senegalia Mellifera* Encroacher Bush when Fed to Weaned Damara Sheep

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ABSTRACT: *Feeds produced from Senegalia mellifera species have not been considered as an alternative feed to livestock during the dry season when rangelands cannot provide quality grazing resources. This study assessed the palatability of feeds developed from Senegalia mellifera when fed to weaned Damara sheep. A Randomized Complete Block Design with sex as the blocking factor was used for the palatability trial with four diets which were randomly allocated to growing sheep. Sixteen male and female weaned Damara sheep of four to five months of age were confined in individual pens of 2.5m x 3m. The trial consisted of a 5-day adaptation period followed by a 12-day trial period. Formulated diets differed (P 0.05) in their DM, OM, EE, NDF, ADF, and ash. The control diet had a higher (P 0.05) NDF concentration compared to diets with 4% urea or 4% NaOH. Feed intake was influenced (P 0.05) by the day and diet x day interactions. Urea (8%) and NaOH (4%) treatments improved the chemical composition and palatability for S. mellifera feed, but the reaction conditions, including chemicals, concentration, moisture content, pH, and duration, need to be optimized to allow greater reduction of the lignin concentration.*

KEYWORDS: *Senegalia mellifera*, Damara sheep, bush encroacher species.

INTRODUCTION

Palatability refers to the qualities of the feed that, along with taste, smell, and sight, help the animal decide what to eat (Aguiar, Pedreira, Giovane & Silva, 2015). Chemical nature, fibre content, tannin presence, seasonal availability of the plant, shape, phenology, maturity level, and development stage are some of the plant variables that influence palatability (Karak, Khan & Hussain, 2012). Anti-nutritional elements like tannins can alter fodder palatability and thus animal preference. When given a choice of feed, ruminant animals such as cattle, sheep, and goats have

varying degrees of sensitivity to palatability criteria (Marten, 1978). Due to a lack of basic nutrients, it has been hard for farmers in dry and semiarid tropical areas to feed their animals, especially domesticated ruminants (Hernandez *et al*., 1998).

Despite the fact that the biomass of the de-bushed encroachers is used as animal fodder, bush encroachment is one of the land degradation factors that decrease livestock productivity in Namibia (Shikangalah & Mapani, 2020). Moore (2001) claims that the only portions of the encroachers that are digested are the leaves, fruits, and seeds, and that the rest may not be digestible due to the high lignin level. Foliage supplements may thus improve the digestion of low nutritional quality basal forages by providing easily fermentable non-structural carbohydrates (Kim, Choung & Chamberlain, 1999). Nonetheless, a few people have been using bush for animal fodder since the 1980s, and the trend has been rising since 2012 (MAWF, 2017a). Up to 75% of all agricultural output is expected to come from livestock production. Beef production will lead the way, followed by sheep and goat production (Sweet & Burke, 2000).

Feeds produced from *Senegalia mellifera* have not been considered as an alternative feed to livestock during the dry season when rangelands cannot provide quality grazing resources. Feeding encroacher bush could be used to feed animals during periods of feed scarcity. Despite the ready availability of encroached bush species such as *Senegalia mellifera*, the use of bush-based animal feeds is limited by poor voluntary intake and low crude protein concentration, which is associated with poor degradability (GIZ, 2016; MAWF, 2017a). Utilization of poor quality forages, for example, wheat straw for feeding livestock, may be constrained by palatability (Ng'ambi & Ngosa, 1995). Alkali treatment (e.g., NaOH and urea) of crop residues improved the feeding value of ruminants (Ali & Jabbar, 2014). According to Sundstol *et al*. (1978), urea and ammonia should be used to make animals easier to digest and eat.

Supplementing ruminant diets with exogenous fibrolytic enzymes has helped improve fibre digestibility, resulting in improved efficiency of feed utilization as reviewed by Sujani & Seresinhe (2015), although some studies did not report any significant performance improvements. The objectives of this experiment were to determine: (i) the nutrient composition of formulated diets from chemically and fibrolytic enzyme-treated Senegalia mellifera samples; and (ii) the palatability of the feeds developed from Senegalia mellifera when fed to weaned Damara sheep. Supplementing ruminant diets with exogenous fibrolytic enzymes has helped improve fibre digestibility, resulting in improved efficiency of feed utilization as reviewed by Sujani and Seresinhe (2015), although some studies did not report any significant performance improvements.

MATERIALS AND METHODS

Animal and housing

Sixteen male and female weaned Damara sheep of four to five months of age were confined in individual pens of 2.5m x 3m. Sheep were weighed at the beginning and end of the adaptation period and also at the end of the feeding trial period. The Damara sheep were treated for internal and external parasites before the beginning of the trial using IVOMEC ® (Merial, South Africa). Each pen had a water container and a feed trough. Pens were situated in a roofed house with open sides. The pens were cleaned and residues of the previous day's feeds were removed before fresh feed was provided.

Experiment 1: Laboratory analysis of feeds and feed formulation

Standard procedures were used to determine chemical components such as crude protein, total ash, ether extract, crude fiber, and nitrogen free extract (Association of Official Analytic Chemists – [AOAC], 1990; AOAC, 2005). Nx6.25 was used to calculate crude protein and NDF, ADF, and ADL were calculated following the published procedures of (Van Soest *et al*, 1991). shown on Table 1.1 below, with a composition of 40% bush mill, 10% *Vachellia erioloba* pods, 25% marula oil cake, 15% yellow maize, 5% molasses and 1% minerals. The fibrolytic enzyme (xylanase and cellulase) was applied at 4% concentration (enzyme) on the day the samples were analyzed in the laboratory for chemical composition.

Experiment 2: palatability trial

A palatability experiment was carried out following the guidelines of the University of Namibia on the welfare of animals. A Randomized Complete Block Design with sex as the blocking factor, was used for the palatability trial with four diets (control, 4% urea, 4% NaOH and fibrolytic enzymes) randomly allocated to growing sheep. The trial consisted of a 5-day adaptation period, followed by a 12-day trial period. The adaptation period was necessary for familiarizing sheep to the bush-based diets and confinement. Diets were formulated based on treated *S. mellifera* and other ingredients as in Table 1.1. The feeds were offered at 09h00 and 15h00 with allowance of six hours feeding time. The refusals were collected, weighed and intake determined by difference.

Table 1.1 The feed ingredients and nutritional composition of different bush feed rations

	Diets			
Ingredients (g/kg)	**0 (control)**	**Urea4D**	**NaOH4D**	**Enzymes4D**
Bush mill	400	400	400	400
Yellow maize	150	150	150	150
Marula oil cake	250	250	250	250
Camel thorn pods	100	100	100	100
Molasses	50	50	50	50
Coarse salt	50	10	10	10
NaOH	0	0	40	0
Urea	0	40	0	0
Enzymes	0	0	0	40
Total	**1000**	**1000**	**1000**	**1000**
Nutrient composition of diets				
CP (g/kg DM)	101.8	125.3	110.4	112.7
NDF (g/kg DM)	481	405.1	350.3	460.2
ME (MJ/kg)	13.5	11.2	11.5	10.8
EE (g/kg DM)	70.9	95.9	98.4	60.5
Ca (g/kg DM)	8.5	6.4	6.7	8.3
Target CP (g/kg)	**10%**	**10%**	**10%**	**10%**

STATISTICAL ANALYSIS

Data obtained for the chemical analysis were subjected to the one way analysis of variance (SAS, 2008) following a completely randomized design, but with subsampling. The experiment unit was the bag of milled *S. mellifera* which had been formulated in a specific way (control, NaOH, urea and enzyme) and from which two subsamples were obtained for laboratory analysis. Due to the subsampling, the correct error term for testing significant effects was therefore the experimental error (Lentner and Bishop, 1993). Phosphorous values were not normally distributed and attempts to transform them to a normal distribution were unsuccessful, hence the Kruskal-Wallis nonparametric test was used. Effects were considered significant at $P < 0.05$. A trend was recognized at $0.05 \leq P \leq 0.1$. Feed intake was analyzed as a randomized complete block design with repeated measurements using the Proc Mixed procedure (SAS, 2008). The Bayesian Information Criteria (BIC) was used to select the best covariance structure, which was used in modeling (Litell *et al*, 1998). The Heterogeneous autoregressive covariance structure was selected

as best. Effects were considered significant at $P < 0.05$, post hoc analyses were carried out in order to check the difference in means. A trend was recognized at $0.05 \leq P \leq 0.1$.

The model for analysis was:

$$y_{ijk} = \mu + \tau_i + t_j + (\tau * t)_{ij} + \varepsilon_{ijk}$$

Where:

y_{ijk} = observation on experimental unit k, on day j, given diet i.
μ = the overall mean
τ_i = the effect of treatment i
t_j = the effect of day j
$(\tau * t)_{ij}$ = the effect of interaction between treatment i and day j
ε_{ijk} = random error

RESULTS

Chemical composition of formulated diets from *Senegalia mellifera*

Formulated diets differed (P <.05) in their DM, OM, EE, NDF, ADF and ash (Table 5.2). Enzyme treated diets, however, did not differ (P >.05) in their NDF concentration from the control. The control diet had higher (P <.05) NDF concentration compared to urea4D and NaOH4D. The control diet did not differ (P >.05) from enzyme4D in the Ca concentration. Chemically treated diets (urea4D, NaOH4D) had a lower (P <.05) Ca concentration than the control. On the other hand, chemically treated diets (urea4D, NaOH4D) had elevated levels of phosphorous compared to the control and enzyme4D diets. Similarly, chemically treated diets (urea4D, NaOH4D) had higher (P <.05) concentration of EE compared to control and enzyme4D diets. The four diets did not differ (P >.05) in CP concentration because they were formulated to be iso-nitrogenous.

Table 1.2. Nutritional composition of diets formulated from *Senegalia mellifera**

Variables (g/kg DM)	Control	Urea	NaOH	Enzyme	R^2	C.V	S.E	P-values
DM	924.9^{b}	937.8^{d}	916.7^{a}	931.2^{c}	0.9	0.5	0.2	< .0001
Ash	86.7^{a}	91.9^{a}	84.1^{a}	88.6^{a}	0.2	9.8	0.4	< .0001
OM	913.3^{a}	908.03^{a}	915.9^{a}	911.4^{a}	0.2	0.9	0.4	< .0001
CP	99.6^{a}	109.3^{b}	105.8^{ab}	101.1^{ab}	0.7	5.04	0.2	< .0001
NDF	481.01^{c}	405.2^{b}	350.3^{a}	460.2^{c}	0.9	6.01	1.2	< .0001
ADF	325.3^{c}	284.2^{b}	234.9^{a}	289.2^{c}	0.9	5.02	0.7	< .0001
Hemicellulose	155.7^{b}	120.9^{a}	115.4^{a}	170.7^{b}	0.9	5.9	0.6	< .0001
EE	70.9^{b}	95.9^{c}	98.4^{c}	60.5^{a}	0.9	5.8	0.2	< .0001
ME (MJ/kg)	13.5^{a}	11.2^{ab}	11.5^{c}	10.8^{c}	0.7	4.8	0.2	< .0001
Phosphorous	2.6^{a}	3.2^{b}	3.6^{c}	2.4^{a}	0.83	5.4	0.05	< .0001
Calcium	8.46^{b}	6.4^{a}	6.7^{a}	8.3^{b}	0.9	7.7	0.03	< .0001

*Variables with different superscript across the rows are different (p <.05). DM = Dry Matter; OM = Organic Matter; Moisture; CP = Crude Protein; NDF = Neutral Detergent Fibre; ADF = Acid Detergent Fibre; EE = Ether Extract; ME = Metabolisable Energy.

urea4D = diet formulated with *S. mellifera* treated with 4% urea; NaOH4D = diet formulated with *S. mellifera* treated with 4% NaOH; enzyme4D = diet formulated with *S. mellifera* treated with fibrolytic enzyme at 4%.

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Palatability results

Feed intake was influenced (P <.05) by day and diet x day interaction. Least squares means of daily intake of different *S. mellifera* bush-based diets fed to the weaned Damara sheep are given in Figure 5.1. The widest fluctuations in feed intake in the first 8 days of the trial were in the control and enzyme4D diets. From day 8 to 12, the feed intake appears to have stabilized across all the diets. All the sheep showed some weight increment at the end of the trial period, but the weight data was not analysed because of the short duration of the feeding period.

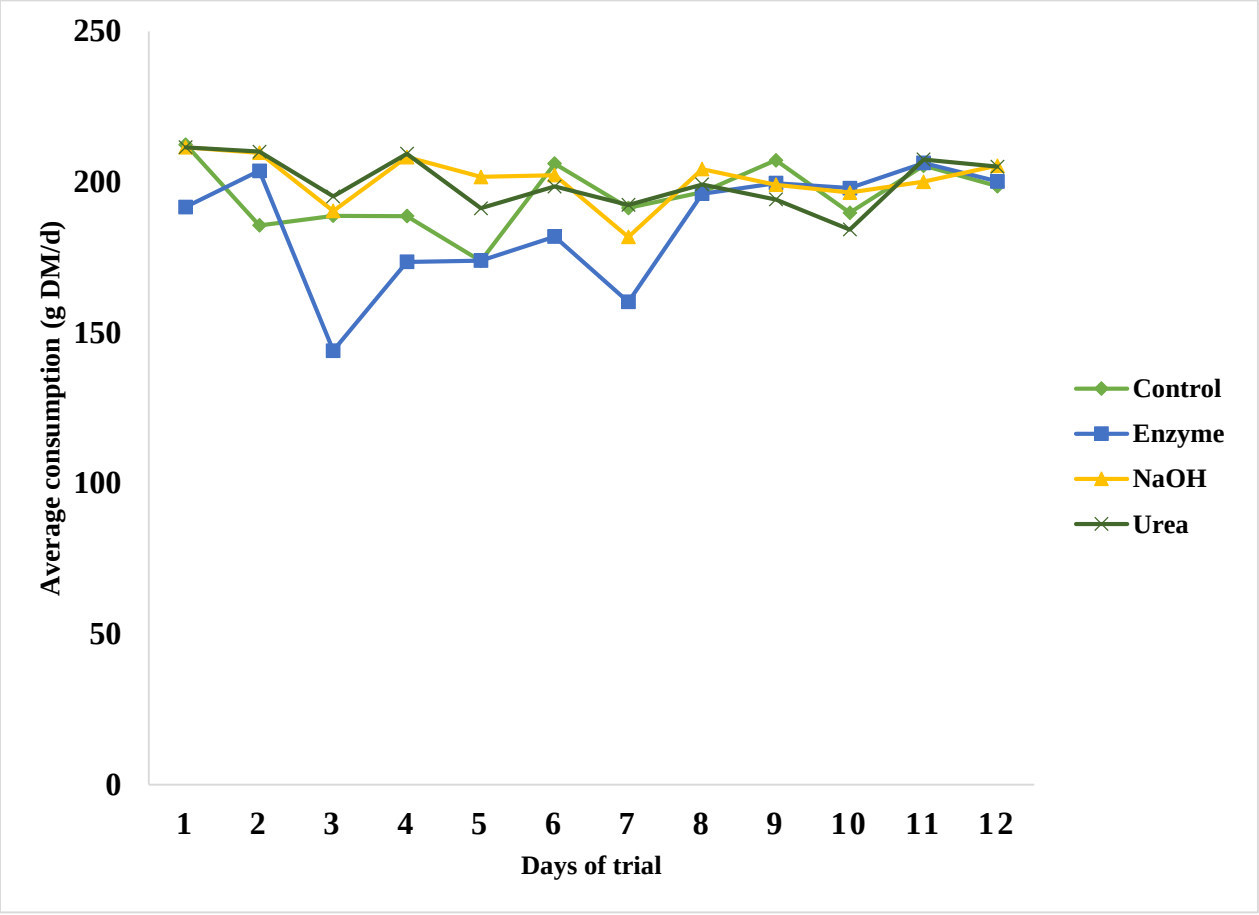

Figure 1.1. Least squares means of feed intake of different *S. mellifera* based diets (control, NaOH, urea and enzyme) fed to weaned Damara sheep.

DISCUSSION

Diets formulated from chemically treated *S. mellifera* were lower in NDF and ADF concentrations, which may suggest improved nutritive value because of the breakage of ester bonds between the cellulose, hemicelluloses and the lignin. This would present opportunities in utilizing encroacher bush, because bush-based feed in Namibia is presently based on untreated bush material (GIZ, 2017). When S*amanea* and *Gliricidia* leaves were mixed with leaves from other fodder trees, the CP content increased significantly, while the NDF content ranged from 30.04 to 40.50%, but the ADF content went from 17.57 to 31.36% (Idan *et al*., 2020). The mixing of treated milled bush material with other ingredients improves the nutritive of the diet by providing readily fermentable sugars (molasses), rumen degradable protein and minerals which may support increased rumen microbial activity for utilization of bush feed. The enzyme treatment did not affect chemical composition of formulated diets from *S. mellifera,* which is not surprising because the enzymatic activity requires an appropriate environment which is only available once the feed has been ingested and reached the rumen.

The two diets (NaOH and urea) were selected for the palatability trial based on a reduction in ADF; the third diet was the enzyme, because of the improved fibre digestibility attributed to fibrolytic enzymes (Sujani & Seresinhe, 2015); the fourth diet was the control. All the diets were iso-nitrogenous with a CP of 10% which was in excess of the 8% required for rumen microbial activity (McDonald *et al*., 2010) and in addition contained molasses which provided readily fermentable sugars and also enhanced palatability. It has been reported that goats consumed 37% more wheat straw organic matter after it had been sprayed by molasses to improve taste and smell (Ng'ambi and Ngosa, 1995), which supports the ready consumption of the *S. mellifera*-based diets observed with the Damara sheep in our study

The NDF concentration of the four diets was also within the acceptable range (< 550 g DM/kg) for ruminant feeding (McDonald *et al*., 2011). Hence the diet formulations, appeared to have been satisfactory for maintenance requirements of the Damara sheep (given that none of the experimental sheep lost weight and in fact gained weight), although fluctuations in intake were still evident after the 5-day adjustment period. The fluctuations during the trial period would suggest that sheep fed bush-based feed may require a longer adjustment period of more than the 5 – 10 day period recommended in some studies using other ingredients (Kaitho *et al*., 1996). Based on our study, the adjustment period for Damara sheep given *S. mellifera* bush-based feed is at least 12 days.

Growing male goats fed wheat straw treated with urea, enzyme and molasses significantly increased in live weight (Allam *et al.*, 2009). All the experimental animals used in our study maintained or gained weight, showing the potential of *S. mellifera* bush-based feed, however, the data was not analysed because of the short duration of the feeding period. Ngwa *et al*. (2003) consumption of hay originally increased during the first 10 days of the trial but decreased dramatically during the last two days, whereas the intake of alfalfa showed the opposite tendency. Also of importance to note was that none of the Damara sheep showed any signs of ill health during the trial period. Animal and plant factors are some of the few factors that might have influenced the differences in dry matter intake as observed in this study. In addition, the presence of tannins which are anti-nutritional factors might also have affected the palatability of bush-based feeds. The control and enzyme4D treated diets were similar ($P > 0.05$) in their NDF concentration, which was higher than for the NaOH and urea diets and this may have adversely affected intake.

Voluntary intake is affected by rumen fill and diets with high NDF concentration will have a reduced passage rate and hence reduced feed intake (Allen, 1996). Although Neutral detergent fiber (NDF) has been used as the only feed aspect to predict the fill effects of forage (Merten, 1987), it may be unsatisfactory and other attributes may influence its fill effects including: initial particle size, fragility of particles, rate and extent of NDF digestion (Allen, 1996). In addition, the greater palatability of the Moringa oleifera and Gliricidia sepium fodders supplied as supple ments to the West African dwarf sheep feed was linked to the higher voluntary feed intakes (Idan *et al*, 2020). We surmise that the gradual stabilization in the feed intakes of the different diets, may be due to changes in the rumen microbial populations with the bush-based feed material, but this requires further investigation.

CONCLUSION

Diets formulated from *S. mellifera* treated with CONTRL, NaOH, urea and enzyme were all palatable, although CONTRL and enzyme required a longer adjustment period, which may be due to the higher NDF concentration. Treatment of *S. mellifera* bush-based feed with NaOH and urea improves intake and this is enhanced by inclusion of molasses and other ingredients (marula oil cake, yellow maize, minerals) in the formulated diets, hence enhancing the utility of this resource for feeding ruminants.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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