Management of Meskit (Prosopis juliflora) Tree in Oman: The Case of Using Meskit (Prosopis juliflora) Pods for Feeding Omani Sheep

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Abstract—This study evaluated the use of raw or processed Prosopis juliflora (Meskit) pods as a major ingredient in a formulated ration to provide an alternative non-conventional concentrate for livestock feeding in Oman. Dry Meskit pods were reduced to lengths of 0.5–1.0 cm to ensure thorough mixing into three diets. Meskit pods were subjected to two types of treatments; roasting and soaking. They were roasted at 150°C for 30 minutes using a locally-made roasting device (40 kg barrel container rotated by electric motor and heated by flame gas cooker). Chopped pods were soaked in tap water for 24 hours and dried for 2 days under the sun with frequent turning. The Meskit-pod-based diets (MPBD) were formulated and pelleted from 500 g/kg ground Meskit pods, 240 g/kg wheat bran, 200 g/kg barley grain, 50 g/kg local dried sardines and 10 g/kg of salt. Twenty four 10-months-old intact Omani male lambs with average body weight of 27.3 kg (± 0.5 kg) were used in a feeding trial for 84 days. They were divided (on body weight basis) and allocated to four diet combination groups. These were: Rhodes grass hay (RGH) plus a general ruminant concentrate (GRC); RGH plus raw Meskit pods (RMP) based concentrate; RGH plus roasted Meskit pods (ROMP) based concentrate; RGH plus soaked Meskit pods (SMP) based concentrate. Daily feed intakes and bi-weekly body weights were recorded. MPBD had higher contents of crude protein (CP), acid detergent fibre (ADF) and neutral detergent fibre (NDF) than the GRC. Animals fed various types of MPBD did not show signs of ill health. There was a significant effect of feeding ROMP on the performance of Omani sheep compared to RMP and SMP. The ROMP fed animals had similar performance to those fed the GRC in terms of feed intake, body weight gain and feed conversion ratio (FCR). This study indicated that roasted Meskit pods based diet may be used instead of the commercial concentrate for feeding Omani sheep without adverse effects on performance. It offers a cheap alternative source of protein and energy for feeding Omani sheep. Also, it might help in solving the spread impact of Meskit trees, maintain the ecosystem and helping in preserving the local tree species.

Keywords—Growth, Meskit, Omani sheep, Prosopis juliflora.

I. INTRODUCTION

Livestock production is an important traditional practice in Oman as it has been an essential component of Omani culture and economics for centuries. Farm animals in Oman are mostly raised under traditional systems based on grazing range plants plus some supplementation. The shortage of fresh water in Oman as in arid regions is a major limiting factor to livestock production as it results in high cost of animal feeds. Generally, animal production systems in Oman are based on feeding RGH as a roughage supplemented with a commercial concentrate or barley. Therefore, replacing these commercial concentrates and barley in Omani ruminant diets would reduce feeding cost consequently increasing economic revenue for livestock farmers.

There are some potential livestock non-conventional feed (NCF) resources in grazing and browsing plant species such as Prosopis spp. [10]–[13]. There are two Prosopis species in Oman, the local P. cineraria (Ghaf) and the introduced P. juliflora (Meskit; mesquite) locally known as "Ghawanafih" or "Al-Ghaf Al-Bahri". P. juliflora, is an evergreen nitrogen-fixing leguminous tree of the Leguminosae family and Mimosoideae subfamily, native to the Americas [16]. It was introduced to Oman last century to combat desertification and for landscaping. Over the years it has been transformed into a pest spreading over large ecosystems competing with, and in many cases eliminating native plant species. Meskit is. Livestock do not consume its leaves but they eat its pods. Its yield of pods was estimated as 3.6 – 4.6 tons/feddan/season [9].

Some experimental work has been carried out around the world with Meskit pods for feeding livestock. Ibrahim and Gaili [9] fed rations containing various levels of Meskit to goats in Sudan. Animals fed 1000 g/kg and 850 g/kg pods of the ration lost weight whereas those fed rations containing 700 and 550 g/kg of the pods gained 162 and 267 g/week. Ali et al. [2] fed P. juliflora pods and leaves to Ethiopian sheep. They concluded that P. juliflora pods may be fed to lambs without adverse effects on growth or carcass characteristics but addition of P. juliflora leaves to sheep diet produced negative effects.

Obeidat et al. [6] studied the effects of inclusion of P. juliflora pods at levels of 100 and 200 g/kg in finishing diets on growth performance, digestibility, and carcass and meat characteristics in Awassi lambs. Dry matter, organic matter (OM), CP, ADF and NDF intake was higher for the 200 g/kg group than the controls while the 100 g/kg group was...
intermediate. Digestibility of DM, OM, CP, NDF, and ADF along with rumen fluid pH and the N retained were similar among all treatment diets. There were no differences between experimental groups in final body weight, total gain, or average daily gain. Lambs receiving no pods had lower FCR than the Prosopis fed lambs. Cost of gain was lower for the 200 g/kg pod sheep when compared to 100 and the control groups, with no differences between the control and the 100 g/kg group. The authors concluded that feeding fattening Awassi lambs diets containing up to 200 Prosopis juliflora pods did not affect growth performance, nutrient digestibility, and carcass and meat characteristics while being cost effective.

In Brazil P. juliflora pods flour replaced up to 600 g/kg of wheat flour in rations of lactating cows. Dry matter (DM) intake, weight gain and milk production increased with an increasing proportion of pod flour [17]. In beef cattle diets, it was possible to totally replace wheat flour with ground pods [17]. In Brazil, [8] indicated that corn replacement with Meskit pod meal should not exceed 405 g/kg although total replacement does not interfere with DM, CP and TDN intake of apparent digestibility of nutrient and most ingestive behaviour parameters. Inclusion of up to 300 g/kg Meskit pods did not affect daily body gain [18].

Research at Sultan Qaboos University indicated the possible use of both P. juliflora and P. cineraria for feeding sheep and goats [10]-[13]. Mahgoub et al. [13] fed rations containing four different levels (0, 100, 200 and 300 g/kg) of dry Meskit pods to Omani native goats with the aim of reducing proportions of RGH in the diet. Feed intake, growth rate and feed conversion were maximized with 200 g/kg Meskit pods in the diet but dropped when Meskit pod proportion in the ration increased to 300 g/kg. However, feeding diets containing levels of Meskit pods up to 300 g/kg did not affect proportions of body components or carcass chemical composition. Mahgoub et al. [12] evaluated the use of a local by-product based concentrate containing Meskit pods to replace a commercial concentrate for native sheep. One group of sheep was fed a concentrate pelleted feed made mainly from local by-products including P. juliflora pods, wheat bran, date syrup and date fibre (a by-product of date syrup industry). The other two groups were fed either a commercial concentrate or a 50:50 mixture of local and commercial concentrate. All groups were fed ad libitum RGH. The animals that were fed the local by-product concentrate had similar feed intake, grew at the same rate and had similar FCR as those fed the other two concentrate rations. There was no effect of diet on haematological parameters or carcass composition. Mahgoub et al. [10] reported that Omani sheep and goats were fed up to 300 g/kg of P. cineraria pods without compromising their performance.

Prospopis pods are good animal feed especially in dry regions with less livestock feed. They contain up to 120 g/kg CP and moderate fibre [12], [13] although its seed protein is deficient in sulphur amino acids but high in lysine and phenylalanine content [16]. About 270-360 g/kg of the CP in the Prosopis pods is associated to the ADF fraction which limits its digestibility and rumen degradability [3]. One of the problems encountered with feeding Meskit is the low level of feed intake of pods by various livestock species. Meskit pods contain anti-nutritional factors (ANF). Meskit seeds contained relatively high trypsin inhibitors plus other ANF such as lectins, alkaloids, saponines and phenols [16]. Processing of the pods to remove factors affecting palatability and anti-nutritional effects would help improving feed intake by animals. Processing may include washing to remove water soluble factors or heat treatment. Ortega-Nieblas et al. [16] reported that thermic treatment increased the digestibility of Meskit seeds by 5-10%. Heat treatment of legume seeds was effective in reducing CP degradability in rumen and improved utilization by various livestock species [3]. Roasting of seeds could reduce or modify the content of thermo labile ANF or modify its structure and activity without altering feed chemical composition or decrease feed digestibility [3].

The current study aimed to investigate processing Meskit pods to improve their intake by livestock. This will provide an alternative protein and energy sources to deprived native Omani livestock. It will also assist in reducing harmful effects on the ecosystems by removing large amounts of Prosopis seeds. The outcome of this project would reduce animal production cost and increase local farmers' revenue.

II. MATERIALS AND METHODS

A. Feeds Preparation and Processing

Dry Meskit pods were collected during the fruit production season and stored in a cool dry shed. The pods were then chopped to lengths of 0.5-1.0 cm before processing and including into the diets to ensure thorough soaking and roasting. Meskit pods were roasted at 150°C for 30 minutes using a locally-made roasting device made up of a 40 kg steel container rotated by an electric motor and heated by gas flame. Ten kg of chopped pods were added to a 30 litre capacity buckets containing 20 litres of tap water. The mixture was left for 24 hours with frequent manual stirring. The pods were then milled in a grinder, mixed with other ingredients and pelleted to minimize feed selection. The Meskit-pod-based diets (MPBD) were formulated from 500 g/kg ground Meskit pods, 350 g/kg wheat bran, 250 g/kg barley grain, 50 g/kg local dried sardines and 10 g/kg of salt. They were then pelleted in a pelleting machine.

B. Chemical Analysis of the Feeds

The chemical composition of the feed ingredients and rations was determined according to standard methods of AOAC [4]. Dry matter was determined by drying in an oven for 24 h at 80°C (Method 934.01). Crude protein (CP) was determined using a Foss Tectator Kieltec 2300Nitrogen/Protein Analyser (Method 976.05). Fat (EE) was determined using a Soxhlet extraction of the dry sample, using petroleum ether (Method 920.39). Ash content was determined by ashing samples in a muffle furnace at 500°C for 24 h (Method
942.05). Acid detergent fibre (ADF) was determined using Cetyltrimethyl ammonium bromide (CTAB) and 1N H2SO4 as described by [20]. Neutral detergent fibre (NDF) was determined using sodium sulphite and sodium lauryl sulphate as described by [20]. ADF was expressed with ash whereas NDF was expressed without ash. Crude fibre (CF) was determined by digesting the feed sample in dilute acid (1.25% H2SO4) and then in dilute alkali (1.25% NaOH) and ashing. Calcium was determined by treating with 0.4% Lanthanum chloride then measured with an atomic absorption spectrophotometer along with standard calcium solution and phosphorus was estimated by Calorimetric Method. Ammonium Molybdate-Vanadate reagent in acidic medium was used to develop the yellow colour which was read at 460 nm in a Spectronic 20 Spectrophotometer along with standard phosphate solution.

**C. Feeding Trial**

Twenty four 10 months-old Omani intact male sheep with average body weight of 27.3 (±0.5) kg were used in the feeding trial. The animals were born and reared at Sultan Qaboos University Agricultural Experiment Station and were subjected to routine animal husbandry management practices. They were weighed, drenched with Ivermectin, vaccinated against small pox and divided into four groups with similar average body weights. The animals were randomly allocated to four dietary treatments with six animals per treatment. The first group was fed a control diet of a commercial concentrate (GRC) (14% CP Oman Feed Mill General Ruminant pellets) plus RGH. The other groups were offered a concentrate containing raw Meskit pods (RMP), roasted Meskit pods (ROMP) or soaked Meskit pods (SMP) based diets plus the RGH. Animals were fed the hay ad libitum individually pens and offered ad daily of 500g of the concentrates with free access to water and minerals blocks. The experiment continued for 84 days with two weeks as adaptation period. The daily offered hay and concentrates and residual of the following day were weighed to determine daily feed intake.

**D. Statistical Analysis**

Analysis of variance [15], was carried out to evaluate the effects of body weight gain, feed intake and FCR parameters using SAS [19] package. Significant differences between treatment means were assessed using the least-significant difference procedure. Interaction between the treatments were excluded from the model when not significant (P>0.05).
TABLE III
PERFORMANCE OF OMANI SHEEP FED DIETS CONTAINING RAW OR PROCESSED MESKIT PODS BASED DIETS

<table>
<thead>
<tr>
<th>Type of diet</th>
<th>Effect of diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRC</td>
<td>RMP</td>
</tr>
<tr>
<td>Numbers of animals</td>
<td>6</td>
</tr>
<tr>
<td>Days of experiments</td>
<td>84</td>
</tr>
<tr>
<td>Total hay intake (kg)</td>
<td>43.36</td>
</tr>
<tr>
<td>Total concentrate intake (kg)</td>
<td>40.11&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Starting body weights (kg)</td>
<td>27.43</td>
</tr>
<tr>
<td>Final body weights (kg)</td>
<td>37.12&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Average daily intake (kg)</td>
<td>0.994&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total weight gain (kg)</td>
<td>9.68&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Average daily gain (kg/d)</td>
<td>0.115&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cost of the feed (US$/ton)</td>
<td>337</td>
</tr>
</tbody>
</table>

<sup>a</sup>: GRC: General Ruminant Concentrate; RMP: Raw Meskit pods based diet; ROMP: Roasted Meskit pods based diet; SMP: Soaked Meskit pods based diet
<sup>b</sup>: SEM: Standard error of means
<sup>c</sup>: p<0.05; **: p<0.01; ***: p<0.001; NS: Non significant. Means on the same row with same superscripted letter do not differ significantly (p>0.05).

B. Feed Intake

The total RGH intake was not significantly different between all experimental groups. Sheep fed the GRC had the highest intake but it was not different from that of ROMP fed animals (Table III). Sheep fed the ROMP had higher concentrate intake than animals fed RMP and SMP. A similar trend was observed for the total feed intake (RGJ plus concentrate) and daily feed intake (Table III).

The concentrate feed intake gradually increased with the progress of the experimental period (Fig. 1) reaching its maximum at Week 11 for sheep fed the GRC and ROMP diet. However, sheep fed RMP or SMP diets, reached their maximum concentrate intake at Week 3 and then there was a decline until the end of the experiment.

C. Body Weight Growth and Feed Conversion

All experimental sheep, fed the GRC or MPBD gained weight throughout the experimental period (Table III and Fig. 2). Those fed the GRC had the highest weight gain followed by the ROMPC sheep with those fed the SMPC having the lowest gain.

FCR (kg feed/kg body weight gain) was the lowest in sheep fed the GRC and the ROMP, while the RMP and SMP fed groups had significantly highest FCR (Table III). A similar trend was observed for the feed conversion efficiency (kg body weight gain/ kg feed). The estimated cost of the MPBC were much cheaper than the GRC concentrate with the RMP been the cheapest among the MPBD (Table III).

IV. DISCUSSION

A. Nutritive Value and Processing of the Feeds

Chemical composition of raw Meskit pods in the current study was comparable to that reported by other workers in...
Oman and elsewhere although there was a wide variation between various studies. Mahgoub et al. [13] reported that Meskit pods contained 930 g/kg Dry matter and on g/kg DM basis they contained: 120 CP, 289 NDF, 170 ADF, 42 acid detergent lignin, 53 ash, 7 calcium and 1 phosphorus. Ali et al. [3] reported (g/kg) 149 CP, 289 NDF, 170 ADF, 42 acid detergent lignin, 53 ash, 7 calcium and 1 phosphorus. Ali et al. [3] reported (g/kg) basis they contained: 120 CP, 26 EE, 317 ADF, 402 NDF, 10000659 which was comparable to those fed GRC. This indicated that diets containing raw or processed Prosopis pods by thermal treatment of pods was apparently useful as sheep fed the ROMPC had higher feed intakes comparable concentrate to those fed the GRC. However, soaking of pods did not improve feed intake. Soaking was meant to remove ANF which is most probably the major cause for reducing pods intake by livestock. Soaking might also have washed out some soluble sugars and carbohydrates which may have led to an increase in the proportions of fibre. Roasting of pods would be feasible for local farmers as it does not require specialized equipments or high skills. The locally-made device used in the current study is simple and uses cheap cooking gas. The ROMP had higher CP than the raw because probably roasting the pods caused some soluble carbohydrates forming some complexes with CP.

Sheep fed RMP or SMP reached maximum concentrate intake at Week 3 later than the CC or ROMP groups with a decline until the end of the experiment. This might be because sheep could not get adapted to the unpalatable bitter taste of RMP and SMP for a longer period of time which indicates that roasting of pods might have improved their palatability. Benjamin et al. [7] also reported that roasting of pods might have improved their palatability. RMP and SMP for a longer period of time which indicates that roasting of pods might have improved their palatability. However, soaking of pods did not improve feed intake. Soaking of SMP required spraying with water to increase the moisture of the mixed ration. The ROMP was the best among MPBD in terms of the pelleting as it did not heat up pelleting machine nor caused clogging or needed spraying with water.

C. Effects of Prosopis Pods on Feed Intake

In general, after a short period of acclimatisation, MPBD were well accepted by sheep. Processing of Prosopis pods by thermal treatment of pods was apparently useful as sheep fed the ROMPC had higher feed intakes comparable concentrate to those fed the GRC. However, soaking of pods did not improve feed intake. Soaking was meant to remove ANF which is most probably the major cause for reducing pods intake by livestock. Soaking might also have washed out some soluble sugars and carbohydrates which may have led to an increase in the proportions of fibre. Roasting of pods would be feasible for local farmers as it does not require specialized equipments or high skills. The locally-made device used in the current study is simple and uses cheap cooking gas. The ROMP had higher CP than the raw because probably roasting the pods caused some soluble carbohydrates forming some complexes with CP.

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D. Body Weight Gain and Feed Conversion

All animals fed the MPBD gained weight during the trial which indicated that diets containing raw or processed Prosopis are suitable for maintaining animals especially during dry season where grazing is scarce. Among these, animals fed the ROMP had the highest body weight gain which was comparable to those fed GRC. This indicated that...
thermal processing of Prosopis pods is beneficial and should be adopted as a strategy to improve the utilization of pod in feeding local livestock.

The average daily growth rates achieved by the GRC and ROMPC experimental groups were comparable to those of Omani sheep fed diets containing Meskit pods [12]. However, the growth rates of the RMP and SMP groups were significantly lower than the other two groups. Yet these feeds may also be used for maintenance of livestock if roasting is not feasible. Mahgoub et al. [13] reported lower body weight gains for Omani sheep fed up to 200 g/kg Meskit pods and weight loss when the proportions increased to 300 g/kg. Abdullah and Abdel Hafes [1] detected no effect of diets that contained Prosopis juliflora pods at the level of 0,150 and 250 g/kg on rate or efficiency of growth. The proportions of the P. juliflora pods in the current study (500 g/kg) were higher yet produced no drastic effects on intake or body gain.

Mahgoub et al. [10] reported similar growth rates in a reduction with growth rate in increasing Prosopis cineraria levels of 300 and 450 g/kg. Similarly [1] reported that the rate and efficiency of growth decreased at higher levels of P. juliflora pods (350 or 450 g/kg). Cumulatively, these studies suggest that low growth rate could have been due to the depression in feed intake that was noticed in previous studies which examined diets containing high levels of Meskit Pods.

In the current study, Omani sheep receiving the ROMP had higher FCR comparable with GRC group. This was the result of high body weight gain and feed intake in this group. Ali et al. [2] reported that sheep fed RGH plus 300 g/kg of ground P. juliflora pods consumed 718 g DM/d and gained 51 g/d which indicates a FCR of 14.4 g feed/g body weight gain which is similar to that in animals fed RMP and lower than in sheep fed ROMP.

V. CONCLUSIONS

All animals fed the MPBD gained weight during the trial which indicated that diets containing raw or processed Prosopis are suitable for maintaining animals especially during dry season where grazing is scarce. Among these, animals fed the ROMP had the highest body weight gain which was comparable to those fed GRC. This indicated that thermal processing of Prosopis pods is beneficial and should be adopted as a strategy to improve the utilization of pods in feeding local livestock.

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