

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

S. Al-Khalasi, O. Mahgoub, H. Yaakub

## I. INTRODUCTION

**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 ( $\pm$  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*.

S. Al-Khalasi is with the Ministry of Agriculture and Fisheries, Muscat, Sultanate of Oman (phone: 00968-99479224; fax: 00968-25-359051; e-mail: saidalkhalasi@gmail.com).

O. Mahgoub is with the Department of Animal and Veterinary Sciences, College of Agricultural and Marine Sciences, Sultan Qaboos University, PO Box 34, Al-Khod 123, Oman (phone: 0096824141248; fax: 0096824413418; email: osmahgob@squ.edu.om)

H. Yaakub is with the Department of Animal Science, Faculty of Agriculture, University Putra Malaysia, Malaysia (phone: 603-8947 4873; fax: 603-89381024; email: hali@upm.edu.my)

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 "Ghowaifah" 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 was 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.

*Prosopis* 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 washed and allowed to dry for 2 days under the sun with frequent turning over. 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 Tecator Kieltec 2300 Nitrogen/Protein Analyser (Method 976.05). Fat (EE) was determined by 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 H<sub>2</sub>SO<sub>4</sub> 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% H<sub>2</sub>SO<sub>4</sub>) 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 ( $\pm$ 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 health 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 ( $P > 0.05$ ).

## III. RESULTS

### A. Chemical Composition of Experimental Rations

Table I gives the proximate chemical composition of the ingredients used in ration formulation. The raw Meskit pods contained lower CP than other feed ingredients but contained comparable NDF and ADF to other feed ingredients except the dried sardines. The gross energy content of the *Prosopis* pods was higher than that in barley grain and dried sardines and was only matched by wheat bran. Dried sardines, which is locally processed and traditionally used for feeding livestock is an excellent cheap source of CP. The ash content of the pods was similar to that in barley and much lower than that in wheat bran or dried sardines. All MPBD contained higher CP levels than the GRC (Table II). These rations also contained lower levels of ash than the commercial concentrate. However, the GRC contained lower levels of fibre (crude, ADF and NDF) than the MPBD. The SMP had higher levels of CF and ADF than other MPBD and RGH. The higher fibre content of the Meskit pod based rations was accompanied by higher gross energy levels (Table II). The MPBD had higher CP, fibre, EE, Ca, P and GE than the RGH (Table II).

TABLE I  
PROPORTIONAL AND CHEMICAL COMPOSITIONS OF THE INGREDIENTS USED IN THE DIETS

Ingredient	Level in the diet (g/kg)	DM g/kg	DM (g/kg)					
			CP	Ash	ADF	NDF	EE	GE (kJ/g)
Meskit pods	500	918.5	104.5	19.8	81.2	432.1	15.3	18.53
Wheat bran	240	903.2	145.1	32.5	125.4	447.8	3.44	18.87
Barley grain	200	938.7	149.2	19.7	79.1	434.1	15.5	15.86
Dried sardines	50	914.2	657.1	267.4	65.4	41.2	46.0	15.64
Salt	10	960	0	0	0	0	0	0

DM= dry matter; CP: Crude protein; ADF: Acid detergent fibre; NDF: Neutral detergent fibre; EE: ether extract; GE: Gross energy

TABLE II  
CHEMICAL COMPOSITIONS OF DIET INGREDIENTS USED IN THE FEEDING TRIAL

Ingredient	Level in the diet (g/kg)	DM <sup>a</sup> (g/kg)								
		CP	Ash	CF	ADF	NDF	EE	Ca	P	GE (kJ/g)
Rhodes grass Hay	927	67.8	97.3	331.4	395.6	676.3	27	0.42	0.21	15.91
GRC	894	117.3	69.8	60.3	72.1	212.1	54	3.52	1.30	16.45
RMP <sup>b</sup>	915	146.9	56.7	143.0	162.8	321.3	45	3.43	1.27	17.20
ROMP	930	132.8	59.3	154.4	182.8	347.4	48	3.31	1.18	17.36
SMP	902	134.6	59.8	176.8	233.1	318.2	49	3.11	0.88	17.25

<sup>a</sup> : DM= dry matter; CP: Crude protein; CF: Crude fibre; ADF: Acid detergent fibre; NDF: Neutral detergent fibre; EE: ether extract; Ca: calcium; P: phosphorus; GE: Gross energy; <sup>b</sup> GRC: General Ruminant Concentrate; RMP: Raw Meskit pods based diet; ROMP: Roasted Meskit pods based diet; SMP: Soaked Meskit pods based diet

TABLE III  
PERFORMANCE OF OMANI SHEEP FED DIETS CONTAINING RAW OR PROCESSED MESKIT PODS BASED DIETS

	Type of diet					Effect of diet
	GRC	RMP	ROMP	SMP	SEM	
Numbers of animals	6	6	6	6		
Days of experiments	84	84	84	84		
Total hay intake (kg)	43.36	43.10	39.40	40.58	1.002	NS
Total concentrate intake (kg)	40.11 <sup>a</sup>	26.99 <sup>b</sup>	36.70 <sup>a</sup>	28.50 <sup>b</sup>	1.389	***
Total feed intake (kg)	83.47 <sup>a</sup>	70.10 <sup>b</sup>	76.11 <sup>ab</sup>	69.10 <sup>b</sup>	1.833	**
Starting body weights (kg)	27.43	27.43	27.43	27.43	0.474	NS
Final body weights (kg)	37.12 <sup>a</sup>	32.28 <sup>b</sup>	35.17 <sup>ab</sup>	30.90 <sup>b</sup>	0.747	**
Average daily intake (kg)	0.994 <sup>a</sup>	0.834 <sup>b</sup>	0.906 <sup>ab</sup>	0.822 <sup>b</sup>	0.022	**
Total weight gain (kg)	9.68 <sup>a</sup>	4.85 <sup>b,c</sup>	7.73 <sup>ab</sup>	3.47 <sup>c</sup>	0.6228	***
Average daily gain (kg/d)	0.115 <sup>a</sup>	0.058 <sup>b,c</sup>	0.092 <sup>ab</sup>	0.041 <sup>c</sup>	0.0074	***
Feed conversion ratio (kg feed/kg body weight)	9.38 <sup>a</sup>	14.70 <sup>ab</sup>	9.99 <sup>a</sup>	26.59 <sup>b</sup>	2.182	**
Feed conversion efficiency (kg body weight/kg feed)	0.12 <sup>a</sup>	0.07 <sup>b,c</sup>	0.10 <sup>ab</sup>	0.05 <sup>c</sup>	0.085	**
Cost of the feed (US\$/ton)	337	228	246	251		

<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>β</sup>: SEM: Standard error of means

\*: 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.

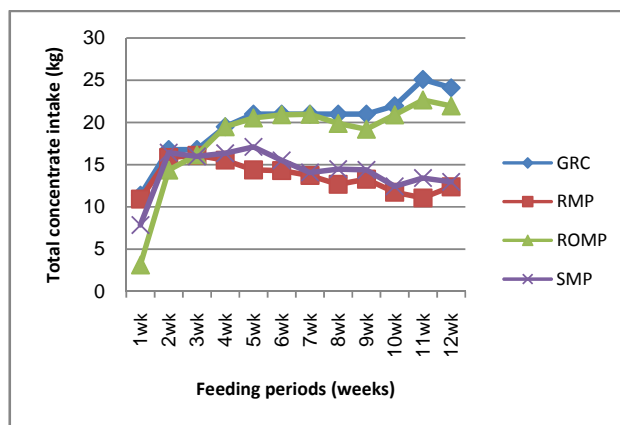


Fig. 2 Weekly total concentrate intakes of Omani sheep fed diets containing raw or processed Meskit pods; GRC: General Ruminant Concentrate; RMP: Raw Meskit pods based diet; ROMP: Roasted Meskit pods based diet; SMP: Soaked Meskit pods based diet

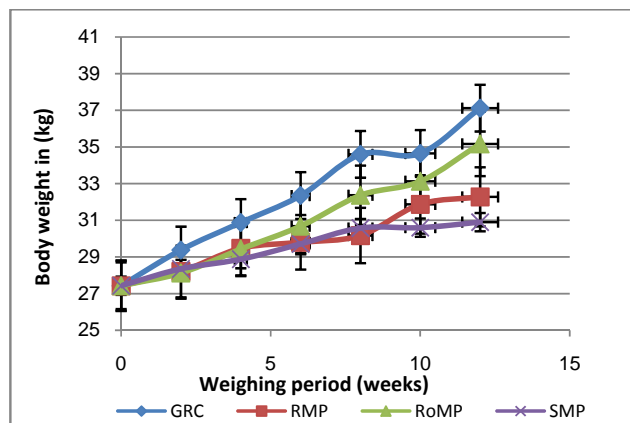


Fig. 1 Growth curves of Omani sheep fed diets containing raw or processed Meskit pods; GRC: General Ruminant Concentrate; RMP: Raw Meskit pods based diet; ROMP: Roasted Meskit pods based diet; SMP: Soaked Meskit pods based diet

### 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, 26 EE, 317 ADF, 402 NDF, 4ash, 7calcium and 1 phosphorus. Ali et al. [3] reported (g/kg) 149 CP, 289 NDF, 170 ADF, 42 acid detergent lignin, 53 ash in *P. juliflora* pods. Comparable chemical composition of pods was reported by [3], [8], [5]. However, [14] reported higher CP levels (287 g/kg) but those were measured in separated *P. Juliflora* seeds rather than the whole pods. The CP levels in the *P. juliflora* pods are adequate for growing sheep.

The fibre levels in Meskit pods were lower than those in RGH and wheat bran and comparable to those in barley grain. Low levels of fibre in the diet enhance digestibility of ruminant's feeds. The Meskit pods had high gross energy levels equal to that of wheat bran and higher than that of barley grain. The low ash levels in the pods are favourable because most non-conventional diet ingredients have high ash levels which limit their inclusion in the rations at high proportions. The commercial concentrate had the lowest fibre indicating that the main ingredients were cereals.

#### *B. Ration Formulation and Effect of Processing on Prosopis Pods*

The MPBD contained Meskit pods, barley, wheat bran and dried sardines. These ingredients are locally produced at low prices (except for the barley). This should reduce feeding cost and consequently increase farmers' revenue and help in disposal of agricultural by-products in an environmental-friendly manner. The current study indicated that estimated prices of all *Prosopis* based diets were lower than that of the commercial concentrate.

Ingredients similar to those used in the current study have been used in previous experiments to formulate NCF that was offered as a total mixed ration [10]-[13]. These NCFs produced encouraging results with Omani livestock. However, animals offered total mixed rations could easily select feed and, consequently avoid some of the unpalatable ingredients such as Meskit pods. In the current experiment, MPBD were pelleted which, insured that all Meskit pods are consumed. Pods were used at 500 g/kg of the concentrate which is a high proportion compared to other reports in the literature. The pelleted Meskit pods concentrates kept well in a cool place throughout the feeding trial with no change of odour or signs of fungal contamination.

The MPBD were almost isonitrogenous and isocaloric with their CP and energy content was higher than commercial concentrate. As for most NCF, MPBD had higher fibre content than the GRC mainly due to the inclusion of the Meskit pods, and the wheat bran. The ROMP had slightly lower CP and higher fibre compared to the other MPBD. Andrade-Montemayor et al. [3] reported that Meskit pods had a high content of soluble protein and anti-nutritional factors, which were reduced by roasting and resulted in changes in NDF and ADF contents. The authors indicated that the increase in fibre

content appeared to be due to the formation of protein complexes with cell wall carbohydrates.

Calcium and phosphorus contents of Meskit pods were comparable to that of GRC with a trend of SMP having lower content of Ca and P probably due to the process of soaking which may have led to leaching some of the minerals. Therefore, mineral supplementation of rations or providing salt licks may be advised.

High proportions of raw Meskit pods in the in RMPC reduced the efficiency of the pelleting machine by clogging and heating up of the pelleting machine due to the sticky substances such as sugars and phenolic compounds. Use of higher level of raw Meskit pods also produced pellets of harder consistency which might be a reason of low feed intake beside their bitter taste. Pelleting 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.

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 *P. Juliflora* pods were not readily eaten especially when ground and when fed alone with the sheep stopped eating altogether after one week. Animals in all experimental groups consumed similar amounts of hay, but due to the difference in the concentrate intake they had a different concentrate: hay ratio.

#### *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 Mesquit 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 Mesquit 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 with a reduction in growth rate with 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 Mesquit 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 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.

#### ACKNOWLEDGMENT

The authors would like to thank Mr. Abdullah Al-Abri, Mr. Rabea Al-Muqbali, Mr. Musab Al-Busaidi and Mrs. Kaadhia Al-Kharousi of the Animal and Veterinary Sciences, Sultan Qaboos University for providing technical help. This study was funded by Sultan Qaboos University, project No. 1G/AGR/ANVI/12/02.

#### REFERENCES

[1] A.Y. Abdullah, B.Y. Abdel Hafes, "Inclusion of *Prosopis juliflora* pods in finishing Awassi lamb diets", Proc. 11<sup>th</sup> AAAP Animal Science Congress, vol. 2, pp. 373–375, 2004.

- [2] A.S .Ali, S.T .Sarawut, R. K. Kaewtrakulpong., "Effect of Feeding *Prosopis juliflora* Pods and Leaves on performance and carcass characteristics of Afar Sheep". KasetsartJ. (Nat. Sci.) 46, 871 – 881, 2012.
- [3] H.M. Andrade-Montemayor, A.V. Bodova-Torres, "Alternative foods for small ruminants in semiarid zones, the case of Mesquite (*Prosopis laevigata* spp.) and Nopal (*Opuntia* spp.)" Small Rumin. Res. 98, 83-92, 2011.
- [4] AOAC, "Official Methods of Analysis, 17th ed. Association of Official Analytical Chemists", Gaithersburg,MD, USA, 2000.
- [5] A.M. Batista, A.F. Mustafa, J.J. McKinnan, S. Kennasha, "In situ ruminal and intestinal nutrient digestibility of mesquite (*Prosopis juliflora*) pods". Anim.Feed Sci. Technol. 100, 107 – 112, 2002.
- [6] B.S. Obeidat, Y.A. Abdullah, F.A. Al-Lataifeh, "The effect of partial replacement of barley grains by *Prosopis juliflora* pods on growth performance, nutrient intake, digestibility, and carcass characteristics of Awassi lambs fed finishing diets". Anim. Feed Sci. Technol. 146, 42-54, 2007.
- [7] Y. Benjamin, j. Bakai, D. Benjamin, R., Eyal, "Edibility and digestibility of mesquite (*Prosopis juliflora* ) pods by sheep". Hassadeh 61, 1359 – 1360, 1981.
- [8] J.P. Cristina, M. L. Pereira, C. A. Santana,D. Oliveira, L. S. Argôlo, H. G. Silva, M. S. Pedreira, P. J. Almeida, A. B. Santos. "Mesquite pod meal in diets for lactating goats". Revista Brasileira de Zootecnia42, 102-108, 2013.
- [9] A.A. Ibrahim, E.S. Gaili., "Performance and carcass traits of goats fed on diets containing different proportions of mesquite (*Prosopis chilensis*)". Trop. Agric. (Trinidad) 62, 97–99, 1985.
- [10] O. Mahgoub, I. T. Kadim, D.S. Al-Ajmi, N.M. Al-Saqry, A.S. Al-Abri, A.R. Ritchie, A.S. Al-Halhali, N.E. Forsberg, "Use of local range tree (*Prosopis* spp.) pods in feeding sheep and goats in the Sultanate of Oman". Options Méditerranéennes. Serie A: Séminaires Méditerranéennes, Numéro 59, 191-195, 2004.
- [11] O. Mahgoub, I. T. Kadim, D.S. Al-Ajmi, N.M. Al-Saqry, A.S. Al-Abri, K. Annamalai, N.E. Forsberg, "Effects of replacing Rhodesgrass (*Chlorisgayana*) hay with ghaf ( *Prosopiscineraria* ) pods on performance of Omani native sheep". Trop.Anim.Hlth. Prod. 36, 281 – 294, 2004.
- [12] O. Mahgoub, I.T. Kadim, E.H. Johnson., A. Srikandakumar, N.M. Al-Saqry, A. Al-Abri., Ritchie, "The use of a concentrate containing Mesquit (*Prosopis juliflora*) pods and date palm by-products to replace commercial concentrate in diets of Omani sheep". Anim. Feed Sci. Technol. 120, 33-41, 2005.
- [13] O. Mahgoub, I.K. Kadim, N.E. Forsberg, D.S. Al-Ajmi, N.M. Al-Saqry, A.S. Al-Abri, K. Annamalai, "Evaluation of . (*Prosopis juliflora*) pods as a feed goats". Anim. Feed Sci. Technol.121, 319-327, 2005b.
- [14] NRC (National Research Council), "Nutrient Requirements of Sheep". National Academy of Sciences, Washington, DC, USA, 1981.
- [15] R.L.Ott., "Analysis of variance in some standard experimental designs". In: Introduction to Statistical Methods and Data Analysis. Duxbury Press, Belmont, CA , pp. 842 – 928, 1993.
- [16] M. Ortega-Nieblas, L. Vázquez-Moreno, M.R. Robles-Burgueño, "Protein quality and antinutritional factors of wild legume seeds from the Sonoran desert". J. Agric. Food Chem. 44, 3130-3132, 1996.
- [17] M.A. Habit, J.C. Saavedra, "The Current State of Knowledge on *Prosopis juliflora*". FAO, Plant Production and Protection Division, Rome, Italy, 1988.
- [18] K. Ravikala, A.M. Patel, K.S. Murthy, K.N. Wadhvani, "Growth efficiency in feedlot lambs on *Prosopis juliflora* based diets".Small Rumin. Res. 16, 227-231, 1995.
- [19] SAS, "User's Guide: Statistics, Version 5. SAS Institute Inc., Cary, NC, USA. 1991.
- [20] P. J Van Soest, J.B. Roberston, B.A. Lewis, "Methods for dietary fibre NDF and non-starch polysaccharides in relation to animal nutrition". J.DairySci.74,3583–3597, 1991.