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Effects of Feeding *Prosopis juliflora* Pods with and Without Exogenous Enzyme on Performance, Meat Quality and Health of Broiler Chickens

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Abstract: Two experiments were conducted to evaluate the use of *Prosopis juliflora* pods as a partial replacement of corn as a source of energy for growing broiler chicken. The main objective of Experiment 1, an ileal digestibility assay, was to assess the nutritional value of *Prosopis juliflora* pods compared with corn for feeding broiler chicken. The two test ingredients, *Prosopis juliflora* pods and corn were given alone to determine apparent metabolizable energy (AME) and apparent ileal digestibility of crude fibre. *Prosopis juliflora* pods had significantly lower AME content (10.64 vs 15.26 MJ/kg) and lower apparent ileal digestibility coefficient for crude fibre (0.24 vs 0.63) than corn ($p<0.001$). The objective of Experiment 2, a growth study, was to test the effect of exogenous enzymes on the nutritive value of *Prosopis juliflora* pods. Three *Prosopis juliflora* pods contents (5, 10 and 15%) with and without enzyme supplementation were evaluated. Daily feed intake, body weight gain and feed conversion ratio were measured. At the end of Experiment 2, 64 birds were randomly selected and slaughtered to evaluate carcase and meat quality characteristics. Substitution of corn by 10 and 15% *Prosopis juliflora* pods significantly depressed AME ($p<0.001$). Enzyme supplementation did not improve crude fibre digestibility. The inclusion of *Prosopis juliflora* pods in the diets, except at 5% decreased average daily gains, feed intake and feed conversion ratio ($p<0.001$). Addition of *Prosopis juliflora* pods caused a significant increase in the weights of total digestive tract, pancreas and caecum ($p<0.01$). Addition of *Prosopis juliflora* pods or the exogenous enzyme had no significant effect on carcase or meat quality characteristics, haematology, serum biochemistry and sensory evaluation. This study indicated that *Prosopis juliflora* pods can be included at levels of 5% in broiler diets without affecting performance.

Key words: Ileal digestibility, *Prosopis juliflora* pods, performance, meat quality, broiler chicks

INTRODUCTION

Oman is one the sub-arid zones countries with hot climate and negligible rainfall. This reduces its competencies of producing cheap animal ingredients. Feed energy is a major related factor in the various animal production systems. Substitute local feed sources to cereal grains, especially corn, have been used in various developed countries. Some precautions should be taken when using unconventional ingredients in poultry feeds as some of them may adversely affect the performance of birds. Oman has witnessed a rapid expansion in modern poultry industry in recent years and is totally dependent on imported ingredients for formulation feeds. *Prosopis juliflora* (Meskit, Mesquite) has been introduced to Oman and their pods can be used as an animal feed ingredient (El Hag *et al*., 2000). Despite the harsh semi-desert conditions of Oman, the Meskit tree grows very well over most of the country especially trees grown for landscaping under irrigation, mostly with treated sewage water. Approximate annual pod yield can reach 100 kg/tree (Felker *et al*., 1984; Shukla *et al*., 1986). A high yield of 169 kg/tree/year has also been reported (Mendes, 1986).

Little work has been carried out to utilize the *Prosopis juliflora* pods in balanced poultry rations as a substitute for other energy sources such as the conventionally used imported corn. Recently, there had been an increasing interest in the use of enzymes for improving digestibility and metabolizable energy of ingredients fed to poultry (Choct, 1997). Use of biotechnology in this respect has not only improved the efficiency of the use of existing or conventional ingredients, but also allowed nutritionists to use unconventional feed ingredients that are often cheaper and readily available in relative abundance. One way to counteract the possible anti-nutritive effects of high fibre contents of these agricultural by products and to improve their nutritive values is to supplement them with enzymes. This is because simple stomach animals such as poultry lack the endogenous enzyme that hydrolyses fibre. Addition of exogenous

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enzymes preparation may therefore, improve the nutritive value of the *Prosopis juliflora* pods and consequently enhance poultry performance.

The objective of Experiment 1 (the ileal digestibility assay) was to assess the nutritive value of *Prosopis juliflora* pods as source of energy. Experiment 2 (a growth study) was designed to evaluate the performance of broiler chickens fed on a corn-soybean meal base diet substituted with 5, 10 or 15% of *Prosopis juliflora* pods with or without the addition of an enzyme preparation.

MATERIALS AND METHODS

Experiment 1 (ileal digestibly assay)

Birds and housing: Forty male and female newly hatched (Cobb 500) strain broiler chickens were housed in suspended grower cages. The cages were located in an environmentally controlled metabolism room maintained at 35°C on day 1 and reduced by 1°C/day until 22°C. Birds had free access to water and feed; lighting was maintained at photo-period of 23 h in every 24 h. Birds were initially allocated to replicate cages was from day 13, with live weights of birds in replicates differed by <10 g. Birds were fed a commercial broiler diet from day one to day 18. The birds were 19 d old at the commencement of the ileal digestibility assay.

Experimental diets and procedures: A corn or *Prosopis juliflora* pod was used as a sole source of dietary energy ingredient. Titanium oxide was used as an indigestible marker. The experimental ingredients and titanium oxide were thoroughly mixed before being cold-pelleted through a 3 mm die. Each of the 2 experimental diets were evaluated with four replicates of a cage with 5 birds each. Experimental diets were fed *ad libitum* for 4 days from 19 to day 23 of age. On day 23, birds were starved for one hour then fed for two hours to ensure sufficient gut fill for digesta sample collection. Birds were then killed by an intra-cardial injection of sodium pentobarbitone. Following dissection of the lower small intestine, digesta sample was gently flushed with distilled water and collected into a collection vessel. Samples from birds in a cage were pooled in order to provide enough samples for chemical analysis following the procedure as described by Al-Marzooqi and Wiseman (2009).

Calculations: The titanium and crude fibre data were used to calculate the coefficient of apparent crude fibre digestibility using the following equation described by Al-Marzooqi and Wiseman (2009):

$$\frac{1-(\text{nutrient dig} \times \text{marker diet})}{(\text{nutrient diet} \times \text{marker dig})}$$

where,

Nutrient dig = Nutrient concentration in digesta;
Marker diet = Titanium concentration in the diet;
Nutrient diet = Nutrient concentration in the diet and
Marker dig = Titanium concentration in the digesta

Apparent metabolizable energy (AME) was calculated using the following equation as described by Scott and Boldaji (1997):

$$\text{AME diet (MJ/kg)} = \text{GE diet} - [\text{GE digesta} \times (\text{M diet}/\text{M digesta})]$$

where,

Ge_{diet} = gross energy of the diet
$GE_{digesta}$ = gross energy of the digesta
M_{diet} = marker concentration in diet sample (g/kg)
$M_{digesta}$ = marker concentration in digesta sample (g/kg)

Experiment 2 (growth study)

Birds and housing: One hundred sixty 1-d-old (Cobb 500) broiler chickens were used. On the day of arrival, the chicks were individually weighed and placed in into narrow weight classes. Birds of relatively high or low boy weight were excluded. Five birds were randomly assigned to each of 32 suspended wire cages (62 x 62 x 37 cm), so that all pens had nearly a similar average initial weight. The cages were kept in an environmentally controlled shed. Lighting of 23-h light and 1 h dark was provided.

Experimental diets: Birds were given *ad libtium* access to experimental diets and water. The compositions of the experimental diets are presented in Table 1. The 4 x 2 factorial arrangements of treatments involved 4 inclusions of *Prosopis juliflora* pods: 0, 5, 10 and 15%, substituting for corn and two Hostazym® microGranulate enzyme contents: 0 and 0.1%. There were four replicates for each of the eight dietary treatments with each replicate cage contained five birds. Treatments/replicate combinations were randomly allocated.

Growth and feed intake: The birds and feed of each cage were weighed at day 0, 7, 14, 21, 28, 35 and 42. All the measurements (growth rate, feed intake and feed conversion ratio) were recorded weekly. This allowed growth rate (GR), feed intake (FI) and feed conversion ratio (FCR) to be determined at these periods.

Collection of excreta: Total collection of excreta was carried out for the determination of AME over three collection periods (d 4 to 7, 21 to 24 and 32 to 35). Feed intake and excreta output were measured daily per cage over a 3 d period. Upon the completion of each excreta collection period, droppings collected over the 3 d were pooled and a representative sub-sample was taken for each cage. The representative samples were then freeze dried, lyophilized to equilibrate with atmospheric

conditions and then ground through a 1 mm sieve grinder for laboratory analysis of gross energy (GE), dry matter (DM) and crude fibre (CF). Samples of each diet were also ground for analysis of GE, DM and CF.

Weight of digestive organs: On day 42, four randomly selected birds from each treatment were selected and sacrificed. The weight of the live bird, carcasses, total digestive tract, small intestine, proventriculus, gizzard, pancreas, heart, liver plus gall bladder and caecum, were recorded.

Carcase and meat quality assessment: Eight carcasses from each treatment group were randomly selected and four were used for each of the carcase and meat quality characteristics. The selected carcasses were placed in labeled plastic bags, stored in a chiller (4°C) for 24 h and then frozen at -20°C for carcasses and meat quality measurements. Carcases were thawed overnight in a chiller at 4°C then weighed. One carcase from each cage was ground and then a sample of approximately 200 g was taken and immediately frozen (-20°C) then subsequently freeze-dried. Sub-samples were used to measure DM, protein, ether extract, ash, calcium (Ca) and phosphorus (P). One type of muscle M. *Pectoralis* from the breast was dissected out from 32 carcases then evaluated for meat quality characteristics. Meat quality measurements includes ultimate muscle pH, Warner-Bratzler (WB) shear force, expressed juice, cooking loss and colour L*, a*, b* were as described by Al-Marzooqi *et al*. (2010).

Sensory evaluation: Sensory evaluation was carried out following the procedure described by Al-Marzooqi *et al*. (2010) and carried out in the Sensory Laboratory equipped with individual booths which consist of a counter top with three sides walls extended from floor to ceiling. Each booth was made in such way that the panelists do not influence each other. All booths were provided with florescent lights to mask color differences between the samples. The meat samples were cut to approximately 2.5 inches cubes. Four coded samples representing the four dietary treatments were traditionally cooked in pressure pots under similar flame strength and cooking duration with no spices or additives. Samples were served twice from each experimental-group and the serving order was randomized according to sample, replicate and assessor. Intensities of tenderness, juiciness, flavor, aroma and desirability were evaluated. Water and crackers were served for cleansing the palate between samples. The scale used for evaluation of sensory attributes ranging from the lowest intensity of each attributes (score 1) to the highest intensity (score 9). Thirty panelists participated in this sensory evaluation which is within the required range.

Blood sample collection: At the end of the experiment (day 42), blood samples were collected from 32 birds (4 birds/dietary treatment; were selected randomly) for the determination of the haematological and serum biochemical parameters. Blood samples were collected from the wing vein using disposable syringes needles (23 gauges). Samples for haematological determination were collected into tubes containing heparin as anticoagulant while serological samples for serum biochemistry determination were collected into tubes without anticoagulant. The samples were kept in an ice box and transferred to the laboratory for further assays.

Haematology and serum biochemistry studies: The following haematological parameters were determined: red blood cell (RBC), packed cell volume (PCV) and haemoglobin (Hb). The mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were calculated (Campbell, 1995), respectively. Haemocytometer was used to count red and total white blood cells while for PCV haematocrit was used. The serum biochemical parameters (albumin, urea, creatinine, total protein, aspartate amino-transaferase (AST) and alanine amino-transferase (ALT) and the serum electrolyte (sodium, potassium, chloride and calcium) were determined by using a CX7/CX7 serum chemistry analyzer (Synchron; Beckman, USA).

Chemical analysis: Samples of feed, ileal digesta and excreta used for laboratory analysis were ground to pass through a 1 mm mesh in a micro-Wiley mill. Samples of feed, ileal digesta and excreta were freeze dried prior to grinding. Duplicate determinations of dry matter, crude protein, ether extract, crude fibre, gross energy, ash, calcium and phosphorus were made according to AOAC (2000). Neutral detergent fibre and acid detergent fibre were determined as described by Van Soest *et al*. (1991). Titanium (the indigestible marker) was analyzed using a modified version of the AOAC method (Short *et al*., 1996). Tannin was determined according to the methods Waterman and Mole (1994). Total non-starch polysaccharide was determined according to the procedure of Englyst *et al*. (1992). Chemical analyses were performed in duplicate and repeated if individual data differed by <5%.

Statistical analysis: The experimental design was a 2* 4 randomized factorial with two levels; with and without enzyme and four levels of *Prosopis juliflora* pods (0, 5, 10 and 15%). Analysis of variance was carried out on weight gain, feed intake, feed conversion ratio, digestive tract organs, carcass composition, meat quality and blood haematology and serum chemistry was accomplished using General Linear Models of the SAS statistical program package (SAS, 2001). 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).

RESULTS

Experiment 1-ileal digestibility assay: The chemical composition and anti-nutritional content of *Prosopis juliflora* pods and corn is summarized in Table 2. Gross energy content of *Prosopis juliflora* pods and corn were 18.7 and 18.1 MJ/kg, respectively. Crude protein was higher by 35% in *Prosopis juliflora* pods (12.8 vs 8.33) than the corn. *Prosopis juliflora* pods contained 83% more crude fibre (18.4 vs 3.12) than corn. *Prosopis juliflora* pods had higher neutral detergent fibre and acid detergent fibre 72.9 and 83.4%, respectively, than corn. Corn had a higher of fat content than *Prosopis juliflora* pods. Lignin was 97%higher in *Prosopis juliflora* pods (4.5 vs 0.13) than corn. The cellulose content in *Prosopis juliflora* pods was higher by 69.5% (32.4 vs 9.87) than in corn. Corn had lower hemicellulose content by 53.5% than the *Prosopis juliflora* pods (6 vs 12.9). *Prosopis juliflora* pods contained 70.2% more total non-starch polysaccharides (28.5 vs 8.48) than corn (Table 2).

Mean digestible coefficients of crude fibre and AME contents of *Prosopis juliflora* pods and corn are given in Table 3. The *Prosopis juliflora* pods had significantly lower digestibility coefficient of crude fibre (p<0.001) than the corn (0.24 vs 0.63). The AME value of *Prosopis juliflora* pods was significantly lower (p<0.001) by 30% as compared to the corn (10.64 vs 15.26).

Experiment 2-growth study: The AME content of the basal diets and test diets with different levels of *Prosopis juliflora* pods estimated between days 4-7, 21-24, 32-35 and overall period 0-42 are presented in Table 4. There was no significant improvement with enzyme supplementation on AME content of the basal and test diets during these three estimated and overall periods. In general diets containing various levels of *Prosopis juliflora* pods with enzyme supplementation had numerically higher AME compared with those without enzyme. However, throughout the overall period (0-42) there was no significant difference (p<0.05) between basal diet without enzyme and the 5% *Prosopis juliflora* pods diet. Increasing *Prosopis juliflora* pods of the test diet resulted in significant (p<0.001) linear decrease in AME value during these periods (Table 4). The AME value of the 15% *Prosopis juliflora* pods diet was the lowest in comparison to the other dietary treatments throughout the overall period (0-42). The AME values increased with the age of birds. Increasing *Prosopis juliflora* pods content of the test diet un-supplemented with enzyme resulted in significant (p<0.001) linear decreases in dietary fibre digestion coefficient (Table 4). A non-significant depression in fibre digestibility was observed when the *Prosopis juliflora* pods increased from 0 to 5% of the diet, whereas the 10 and 15% *Prosopis juliflora* pods inclusion resulted in significant depression in fibre digestibility compared with the basal diet (p<0.001). Although, there was an improvement in fibre digestibility as the birds grew older, the improvement was not statistically significant.

The feed intake (g/bird/d), daily gain (g/bird/d) and feed conversion ratio (g Fl/g Gain) for the overall period (0-42) and on weekly basis are presented in Table 5. The inclusion level of *Prosopis juliflora* pods had significant effects on feed intake in week 1, 2, 3, 4, 5 and 6. Birds on diet 10 and 15% consumed less than the other groups. Daily weight gain was also significantly influenced by the inclusion level of *Prosopis juliflora* pods in week 1, 2, 3, 4, 5 and 6. Birds fed diet 10 and 15% *Prosopis juliflora* pods gained less than the other groups. Feed conversion ratio was significantly affected by the inclusion level of *Prosopis juliflora* pods in week 3, 4, 5 and 6. Birds on diet 10% had 0.17, 0.09, 0.08 and 0.11 (g Fl/g Gain) more FCR than the other groups fed basal and the 5% diets. Birds on diet 15% had 0.36, 0.15, 0.1 and 0.18 (g Fl/g Gain) more FCR than the other groups given basal and the 5% diets. There were no significant differences in feed intake, daily gain and feed conversion ratio in bird fed 0, 5, 10 or 15% *Prosopis juliflora* pods diets with or without enzyme supplementation.

Throughout the experimental period (0-42 days), the use of *Prosopis juliflora* pods at 5% level did not affect feed intake, daily gain and feed conversion ratio. During this period (0-42 days), birds fed diet 10 and 15% *Prosopis juliflora* pods, feed intake was significantly reduced by 4.7 and 9.6%, respectively. However, when the mean weight gain for the overall period (0-42 days) was considered, birds fed diet 10 and 15% *Prosopis juliflora* pods, body weight gain was significantly depressed by 7.2 and 14%, respectively. In addition, feed conversion ratio was also poor during over all period (0-42 days). The corresponding feed conversion ratios were significantly reduced by 2.6% (1.94 vs 1.99) and 5.7% (1.94 vs 2.06), when 10 and 15% of *Prosopis juliflora* pods was included into the basal diet. The inclusion of *Prosopis juliflora* pods in the diets more than 5% caused a decrease in the daily gain, feed intake and feed conversion ratio (Table 5).

The weight of total digestive tract, small intestine, proventriculus, gizzard, heart, liver, pancreas and caeca per unit body weight (g/kg body weight) are presented in Table 6. The weight of total digestive tract, small intestine, pancreas and caeca significantly increased with increasing *Prosopis juliflora* pods levels up to 15% in the diet. Adding enzyme to the experimental diets has no significant effect on the weight of proventriculus, gizzard, heart and liver.

Table 1: Composition of the experimental diets (g/kg dry matter) used in the experiment 2-growth study

			Prosopis juliflora pods inclusion (%)					
	Basal	Basal	5		10		15	
Diet[1] enzyme	-Enz	+Enz	-Enz	+Enz	-Enz	+Enz	-Enz	+Enz
Prosopis pods	0	0	5	5	10	10	15	15
Crushed corn	40	40	35	35	30	30	25	25
SBM46%	41	41	39	39	39	39	40.5	40.5
Wheat bran	6.5	6.5	7.25	7.25	6	6	3.75	3.75
Barley	2.3	2.3	5.5	5.5	6	6	2.5	2.5
Vegetable fat	0.1	0.1	0.1	0.1	0.1	0.1	1.5	1.5
Premix[2]	0.3	0.3	0.45	0.45	0.45	0.45	0.45	0.45
Salt	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Limestone	3	3	3	3	3	3	3	3
Dicalcium phosphate	3	3	3	3	3	3	3	3
Binder	3.5	3.4	0.4	0.3	1.15	1.05	4	3.9
Enzyme	0	0.1	0	0.1	0	0.1	0	0.1
Titanium oxide	1	1	1	1	1	1	1	1
Chemical analysis								
Dry matter	88.1		89.8		89.3		86.9	
ME (MJ kg-1)	13.6		13.6		13.5		13.4	
Crude protein (%)	23.3		23.0		23.0		23.1	
Fat (%)	2.23		2.09		2.04		3.09	
Crude fiber (%)	2.90		3.90		4.61		4.99	
Phosphorus (%)	0.99		0.98		0.95		0.91	
Calcium (%)	1.93		1.94		1.95		1.97	

[1]Basal-Enz: Basal diet without enzyme, Basal+Enz: Basal diet with enzyme, 5% *Prosopis juliflora* Pods-Enz: without enzyme, 5% *Prosopis juliflora* Pods+Enz: with enzyme, 10% *Prosopis juliflora* Pods-Enz: without enzyme, 10% *Prosopis juliflora* Pods+Enz: with enzyme, 15% *Prosopis juliflora* Pods-Enz: without enzyme, 15% *Prosopis juliflora* Pods+Enz: with enzyme

[2]The vitamin and mineral premix provide the following quantities per kilogram of diet: Vitamin A, 10,300 IU; Vitamin D3, 2,500 IU; Vitamin E, 40.00 mg; Vitamin K, 3.75 mg; Vitamin B, 1.00 mg; Vitamin B2, 6.50 mg; Vitamin B6, 6.00 mg; Vitamin B12, 0.01 mg; Calcium pantothenate, 18.00 mg;Niacin, 30.00 mg; Folic acid, 2.00 mg; Biotin, 0.06 mg; Flovomycin, 50.00 mg; Ethoxyquin, 125.00 mg; Choline, 650.00 mg; molybdenum, 2.00 mg; Manganese, 120.00 mg; Iron, 7.00 mg; Cobalt, 1.00 mg; Zinc, 90.00 mg; Iodine, 1.50 mg; Selenium, 0.15 mg

Table 2: Chemical composition (%DM) and anti-nutritional contents in *Prosopis juliflora* pods and corn

Chemical composition (DM %)	*Prosopis juliflora* pods	Corn
DM	90.2	89.9
GE (MJ/kg)	18.7	18.1
CP	12.8	8.33
CF	18.4	3.12
EE	1.1	2.2
Ash	5.1	1.9
Lignin	4.5	0.13
Cellulose	32.4	9.87
Hemicellulose	12.9	6.0
Total non-starch polysaccharides	28.5	8.48
Anti nutritional factors (g/kg)		
Tannin	1.8	-

DM: dry matter, GE: gross energy, CP: crude protein, EE: ether extract

The carcass chemical composition and meat quality characteristics of broilers fed different diets is presented in Table 7. Replacing 5, 10 or 15% of corn ingredient with *Prosopis juliflora* pods without or with supplementation of enzyme had no significant effect on broiler carcass chemical composition. There was no effect of *Prosopis juliflora* pods nor enzyme supplementation on broiler meat quality characteristics (color, pH, expressed juice, Warner-Bratzler shear values, Myofibiril fragmentation index and cooking loss%).

Sensory evaluation of broiler chicken meat fed various levels of *Prosopis juliflora* pods diets supplemented with and without enzyme is presented in Table 8. Replacing 5, 10 or 15% of corn ingredient with *Prosopis juliflora* pods without or with supplementation of enzyme had no significant effect on sensory evaluation of broiler chicken.

The haematological, serum electrolytes and serum chemistry of broiler chicken fed various levels of *Prosopis juliflora* pods diets supplemented with and without enzyme are presented in Table 9. Replacing 5, 10 or 15% of corn ingredient with *Prosopis juliflora* pods without or with supplementation of enzyme had no significant effect on broiler haematological, serum electrolytes and serum biochemical components.

DISCUSSION

Experiment 1-ileal digestibility assay: Mesquite pods contain a high proportion of carbohydrates and show that they are a potential source of energy, but its composition varies with location (Chopra and Hooda, 2001); increase rainfall (Sharma *et al*., 1994); season and year (Talpada *et al*., 1989a) and soil type (Mendes, 1986). The composition of *Prosopis juliflora* pods and its nutrients digestibility's fibre content were not been studied. Although *Prosopis juliflora* pods had 3% more gross energy than the corn, its AME content was less. Corn yielded 30% more AME than the *Prosopis juliflora* pods and this is probably due to the higher indigestible fibre content in *Prosopis juliflora* pods (83%). The present study showed that the fibre digestibility in the *Prosopis juliflora* pods was lower than

Table 3: Mean digestible coefficients of crude fibre and apparent metabolizable energy contents of *Prosopis juliflora* pods and corn

Parameters	*Prosopis juliflora* pods	Corn	SEM	Significance
Crude fiber	0.24^{b}	0.63^{a}	0.019	***
AME (MJ/kg)	10.64^{b}	15.26^{a}	0.275	***

SEM: Standard error of mean. ***p<0.001. Means with same row with different letters were significantly different (p<0.001)

Table 4: Effects of *Prosopis juliflora pods* diets supplemented with (+Enz) and without (-Enz) enzyme on apparent metabolizable energy and fibre digestibility coefficient

			---------- *Prosopis juliflora* pods inclusion (%) ----------									
	----- Basal diet ------		5	5	10	10	15	15		--------- Significance ---------		
Diet enzyme	-Enz	+Enz	-Enz	+Enz	-Enz	+Enz	-Enz	+Enz	SEM	Level	Enz	Level*Enz
Apparent metabolizable energy period (day)												
(4-7)	14.0^{ab}	14.1^{a}	14.1^{a}	14.2^{a}	13.3^{c}	13.4^{bc}	11.9^{d}	12.4^{d}	0.14	***	NS	NS
(21-24)	14.2^{ab}	14.3^{a}	14.3^{a}	14.3^{a}	13.5^{c}	13.6^{bc}	12.1^{d}	12.6^{d}	0.14	***	NS	NS
(32-35)	14.4^{ab}	14.5^{a}	14.5^{a}	14.6^{a}	13.7^{c}	13.8^{bc}	12.3^{d}	12.8^{d}	0.17	***	NS	NS
Overall (0-42)	14.2^{ab}	14.2^{a}	14.3^{a}	14.3^{a}	13.5^{c}	13.5^{bc}	12.1^{d}	12.6^{d}	0.14	***	NS	NS
Fibre digestibility coefficient period (day)												
(4-7)	0.33^{ab}	0.34^{a}	0.31^{ab}	0.33^{ab}	0.28^{ab}	0.29^{ab}	0.26^{b}	0.26^{b}	0.016	***	NS	NS
(21-24)	0.36^{ab}	0.37^{a}	0.34^{ab}	0.36^{ab}	0.31^{ab}	0.32$_{ab}$	0.29^{b}	0.29^{b}	0.016	***	NS	NS
(32-35)	0.38^{ab}	0.40^{a}	0.37^{abc}	0.40$_{ab}$	0.34$_{bcd}$	0.35$_{abcd}$	0.31^{d}	0.32^{cd}	0.012	***	NS	NS
Overall (0-42)	0.35^{ab}	0.37^{a}	0.34^{abc}	0.36^{ab}	0.31^{abc}	0.32^{abc}	0.28^{c}	0.30^{bc}	0.014	***	NS	NS

SEM: Standard error of mean. ***p<0.001. NS: Not significant. Means with same row with different letters were significantly different (p<0.05)

Table 5: Effect of *Prosopis juliflora pods* diets supplemented with (+Enz) and without (-Enz) enzyme on feed intake (FI, g/bird/d), daily gain (DG, g/bird/d) and feed conversion ratio (FCR, g feed/g gain)

			---------- *Prosopis juliflora* pods inclusion (%) ----------									
	----- Basal diet ------		5	5	10	10	15	15		--------- Significance ---------		
Diet Enz.	-Enz	+Enz	-Enz	+Enz	-Enz	+Enz	-Enz	+Enz	SEM	Level	Enz	Level*Enz
Stages												
Week 1												
FI	14.52^{a}	14.82^{a}	14.44^{a}	14.67^{a}	13.23^{b}	13.33^{b}	12.10^{c}	12.24^{c}	0.199	***	NS	NS
DG	12.62^{a}	12.66^{a}	12.40^{a}	12.7^{a}	11.25^{b}	11.41^{b}	10.40^{c}	10.47^{c}	0.138	***	NS	NS
FCR	1.15^{a}	1.17^{a}	1.17^{a}	1.15^{a}	1.17^{a}	1.17^{a}	1.16^{a}	1.17^{a}	0.020	NS	NS	NS
Week 2												
FI	48.62^{a}	49.24^{a}	48.43^{a}	49.19^{a}	43.87^{b}	44.15^{b}	38.42^{c}	39.0.^{c}	0.903	***	NS	NS
DG	35.66^{a}	36.02^{a}	37.70^{a}	36.09^{a}	31.38^{b}	31.67^{b}	27.22^{c}	27.84^{c}	0.678	***	NS	NS
FCR	1.37^{a}	1.37^{a}	1.36^{a}	1.37^{a}	1.40^{a}	1.39^{a}	1.41^{a}	1.40^{a}	0.042	NS	NS	NS
Week 3												
FI	80.67^{a}	81.29^{a}	80.96^{a}	81.34^{a}	74.94^{b}	75.13^{b}	68.40^{c}	69.09^{c}	1.14	***	NS	NS
DG	52.22^{a}	52.72^{a}	51.73^{a}	52.30^{a}	43.96^{b}	44.41^{b}	36.18^{c}	36.81^{c}	1.46	***	NS	NS
FCR	1.54^{b}	1.54^{b}	1.57^{b}	1.56^{b}	1.71^{ab}	1.7^{ab}	1.90^{a}	1.88^{a}	0.051	***	NS	NS
Week 4												
FI	115.51^{a}	115.82^{a}	115.08^{a}	115.33^{a}	105.24^{b}	106.78^{b}	97.88^{c}	98.15^{c}	1.48	***	NS	NS
DG	67.21^{a}	67.77^{a}	66.68^{a}	67.26^{a}	58.28^{b}	59.89^{b}	52.31^{c}	53.22^{c}	0.895	***	NS	NS
FCR	1.72^{a}	1.71^{a}	1.72^{a}	1.71^{a}	1.81^{a}	1.79^{a}	1.87^{a}	1.84^{a}	0.043	**	NS	NS
Week 5												
FI	143.77^{a}	144.70^{a}	143.97^{a}	143.38^{a}	138.41^{b}	139.01^{b}	132.37^{c}	133.19^{c}	0.852	***	NS	NS
DG	74.55^{a}	74.55^{a}	73.72^{ab}	74.36^{a}	68.94^{b}	69.31^{b}	64.99^{c}	65.62^{c}	0.688	***	NS	NS
FCR	1.93^{b}	1.94^{ab}	1.95^{ab}	1.93^{b}	2.01^{ab}	2.01^{ab}	2.03^{a}	2.03^{a}	0.02	***	NS	NS
Week 6												
FI	157.39^{a}	157.98^{a}	157.12^{a}	157.79^{a}	150.68^{b}	151.56^{b}	144.15^{c}	14584^{c}	1.03	***	NS	NS
DG	80.92^{a}	81.62^{a}	79.91^{a}	80.69^{a}	72.88^{b}	73.06^{b}	66.25^{c}	66.55^{c}	1.30	***	NS	NS
FCR	1.95^{b}	1.93^{b}	1.97^{b}	1.95^{b}	2.06^{ab}	2.08^{ab}	2.13^{a}	2.19^{a}	0.035	***	NS	NS
Overall												
FI	91.79^{a}	92.95^{a}	91.91^{a}	92.0^{a}	87.50^{b}	88.36^{b}	83.73^{c}	84.08^{c}	0.430	***	NS	NS
DG	47.28^{a}	47.78^{a}	47.24^{a}	47.95^{a}	43.95^{b}	44.34^{b}	40.75^{c}	41.08^{c}	0.599	***	NS	NS
FCR	1.94^{ab}	1.94^{ab}	1.94^{ab}	1.91^{ab}	1.99^{ab}	1.99^{ab}	2.06^{a}	2.05^{a}	0.025	***	NS	NS

SEM: Standard error of mean. ***p<0.001. NS: Not significant. Means with same row with different letters were significantly different (p<0.05)

in corn. The apparent ileal digestibility coefficient of corn fibre was 62% higher than *Prosopis juliflora* pods. The decrease in the AME value of *Prosopis juliflora* pods indicated that its high fibre content had a significant effect on the digestibility. The cellulose, hemicellulose and total non-starch polysaccharides content in *Prosopis juliflora* pods was higher by 69.5, 53.5 and 70.2% than in corn. However, in the current study, the tannin value of the pods obtained was within acceptable range and similar to previous studies (Talpada *et al*., 1989b; Makkar *et al*., 1990). The condensed tannins level in the mesquite pods were below the levels that can cause negative effect on the bird's performance (Makkar *et al*., 1990). The results of this preliminary study indicate that *Prosopis juliflora* pods has the potential to partially replace corn as a source of energy.

Table 6: Mean weight of digestive organs per unit body weight (g/kg body weight) in birds fed on basal and *Prosopis juliflora* pods diets with (+Enz) and without (-Enz) enzyme

	---------- *Prosopis juliflora* pods inclusion (%) ----------											
	---- Basal diet ----		5	5	10	10	15	15		-------- Significance --------		
Diet enzyme	-Enz	+Enz	-Enz	+Enz	-Enz	+Enz	-Enz	+Enz	SEM	Level	Enz	Level*Enz
Total digestive tract	10.7^{c}	11.2^{bc}	11.1^{bc}	12.0^{bc}	12.4^{abc}	12.8^{ab}	13.7^{a}	13.0^{a}	0.46	**	NS	NS
Small intestine	4.7^{c}	5.0^{c}	4.8^{c}	5.0^{c}	6.4^{b}	6.7^{b}	8.2^{a}	8.8^{a}	0.28	***	NS	NS
Proventriculus	0.49^{a}	0.50^{a}	0.50^{a}	0.50^{a}	0.51^{a}	0.51^{a}	0.51^{a}	0.51^{a}	0.03	NS	NS	NS
Gizzard	2.0	2.03	2.03	2.05	2.18	2.19	2.14	2.16	0.11	NS	NS	NS
Heart	0.42^{a}	0.42^{a}	0.75^{a}	0.44^{a}	0.83^{a}	0.42^{a}	0.43^{a}	0.52^{a}	0.17	NS	NS	NS
Liver	2.1^{a}	1.9^{a}	1.7^{a}	2.1^{a}	1.8^{a}	2.10^{a}	2.2^{a}	2.6^{a}	0.26	NS	NS	NS
Pancreas	1.7^{c}	1.7^{c}	1.7^{c}	1.7^{c}	1.8^{b}	1.8^{ab}	1.9^{ab}	1.9^{a}	0.02	***	NS	NS
Cacea	4.6^{d}	4.7^{d}	4.7^{d}	4.8^{d}	6.3^{c}	6.3^{bc}	6.9^{ab}	6.9^{a}	0.13	***	NS	NS

SEM: Standard error of mean. **p<0.01, ***p<0.001. NS: Not significant. Means with same row with different letters were significantly different (p<0.01)

Table 7: Effects of *Prosopis juliflora* pods diets supplemented with (+Enz) and without (-Enz) enzyme on broiler carcass chemical composition and meat quality characteristics of broiler breast (*M. pectoralis*)

	---------- *Prosopis juliflora* pods inclusion (%) ----------											
	Basal	Basal	5	5	10	10	15	15		-------- Significance --------		
Diet enzyme	-Enz	+Enz	-Enz	+Enz	-Enz	+Enz	-Enz	+Enz	SEM	Level	Enz	Level*Enz
Carcass composition												
Dry matter	73.9	70.4	67.5	72.1	66.6	66.6	71.10	75.6	4.06	NS	NS	NS
Protein	77.3	81.3	81.1	79.9	82.1	80.7	80.6	80.7	1.02	NS	NS	NS
Fat	10.1	7.4	6.5	7.4	6.1	6.90	6.02	4.80	1.31	NS	NS	NS
Ash	4.41	4.35	4.32	4.33	4.21	4.41	4.29	4.55	0.124	NS	NS	NS
Calcium	958.9	929	916.5	950.8	963.2	974.3	969.1	943.83	18.35	NS	NS	NS
Phosphorus	382.5	362.5	377.5	370.0	370.0	370.0	372.5	377.5	14.13	NS	NS	NS
Meat quality characteristics (*M. pectoralis*)												
pH	5.55	5.61	5.53	5.55	5.53	5.46	5.50	5.64	0.037	NS	NS	NS
Cooking loss (%)	25.8	20.8	21.34	22.01	24.00	21.41	22.15	24.48	2.26	NS	NS	NS
Expressed juice (cm^2/gm)	28.9	27.8	31.96	33.91	32.20	30.85	27.63	29.85	3.04	NS	NS	NS
WB-shear force value (kg)	1.85	1.70	2.00	2.00	1.89	2.12	2.36	2.09	0.255	NS	NS	NS
SL (µm)	1.75	1.66	1.70	1.57	1.69	1.66	1.68	1.67	0.066	NS	NS	NS
MFI (%)	69.1	73.27	81.75	79.91	66.04	64.05	58.03	57.80	8.51	NS	NS	NS
Lightness (L^*)	50.6	49.6	51.86	48.26	52.85	46.16	44.37	48.57	3.24	NS	NS	NS
Redness (a^*)	8.88	8.44	8.19	8.75	8.35	8.03	9.46	9.01	1.42	NS	NS	NS
Yellowness (b^*)	9.89	10.48	9.75	9.00	9.84	7.79	8.06	10.11	1.21	NS	NS	NS

SEM: Standard error of mean. *p<0.05. NS: Not significant. Means with same row with different letters were significantly different (p<0.05). SL: Sarcomere length (µm) MFI: Myofibiril fragmentation index (%)

Experiment 2-growth study: Cereals are the main source of energy for chickens, among them corn which is the main energy source in poultry rations. The high cost of corn has resulted in increased cost of poultry production across worldwide in general and in Oman in particular and consequently lowering the margin of profit. As the prices of conventional feed ingredients like corn continue to increase, it has become crucial to explore alternatives such as *Propsopis juliflora* pods. Because of the lack of information on the apparent metabolizable energy (AME) of *Prosopis juliflora* pods, the results of the present study will be discussed in light of outcomes of other non-conventional ingredients used in poultry diets. The conventional definition of dietary fibre is a component of a plant feedstuff that cannot be broken down by the enzymes of the bird digestive system and absorbed before the end of the small intestine (Monro, 1993). Most of the unconventional feed ingredients, such as *Prosopis juliflora* pods contain compounds that fit the above definition of fibre. Therefore, exogenous enzyme preparation was added in an attempt to improve the nutritive value of *Prosopis juliflora* pods.

In the present study, there was no significant difference (p<0.05) between basal diet without enzyme and the 5% *Prosopis juliflora* pods level. However, Increasing *Prosopis juliflora* pods of the test diet resulted in significant (p<0.001) linear decrease in AME. Similar findings were represented by different studies when unconventional feed ingredients were used as a source of energy partially replacing the corn in broiler diets (Al-Marzooqi *et al*., 2000). This indicates that *Prosopis juliflora* pods may contain factors that negatively affect digestion. This can be attributed to the presence of a high level of crude fibre in *Prosopis juliflora* pods. The crude fibre content of *Prosopis juliflora* pods obtained in this study was 18.4% DM which was in line with the finding of Shukla *et al*. (1986) who reported contents of 16-34% crude fibre for *Prosopis juliflora* pods on a dry matter basis. Although, there was a depression in AME values with increasing levels of *Prosopis juliflora* pods, the AME values increased with bird age. This suggests that low AME utilization at a younger age is more likely to be associated with undeveloped intestinal absorptive surface and low pancreatic secretion rather than insufficient feed enzymes activity. Similar to the current

Table 8: Sensory evaluation for broiler chicken meat fed various levels of *Prosopis juliflora* pods diets supplemented with (+Enz) and without (-Enz) enzyme

	---------- *Prosopis Juliflora* pods inclusion (%) ----------											
	---- Basal diet -----		5	5	10	10	15	15		---------- Significance ----------		
Diet enzyme	-Enz	+Enz	-Enz	+Enz	-Enz	+Enz	-Enz	+Enz	SEM	Level	Enz	Level*Enz
Tenderness[a]	6.17	6.73	5.77	5.37	5.73	6.2	6.00	6.13	0.378	NS	NS	NS
Juiciness[b]	5.53	5.50	5.07	4.90	5.10	5.83	5.90	5.70	0.385	NS	NS	NS
Flavor[c]	5.37	5.83	5.17	5.37	5.63	5.50	5.00	5.33	0.371	NS	NS	NS
Aroma[d]	5.17	5.03	4.67	5.67	5.6	5.47	5.53	5.90	0.408	NS	NS	NS
Desirability[e]	4.97	5.77	4.87	4.30	5.47	5.27	5.60	5.50	0.430	NS	NS	NS

Score range 9 (highest affirmative value) to 1 (lowest value). Total of 30 panellists participated in the evaluation

[a]Scored as 1 = extremely tough, 9 = extremely tender. [b]Scored as 1 = extremely dry, 9 = extremely juicy. [c]Scored as 1 = extremely undesirable flavor, 9 = extremely desirable flavor. [d]Scored as 1 = extremely having smell, 9 = extremely having no smell [e]Scored as 1 = extremely undesirable, 9 = extremely desirable. SEM: Standard error of mean. **p<0.05. NS: Not significant

Table 9: Haematological, Serum chemistry and Serum electrolyte parameters of broiler chicken fed on basal and *Prosopis juliflora* pods diets supplemented with (+Enz) and without (-Enz) enzyme

	---------- *Prosopis Juliflora* pods Inclusion (%) ----------											
	---- Basal diet ----		5	5	10	10	15	15		------- Significance -------		
Diet enzyme	-Enz	+Enz	-Enz	+Enz	-Enz	+Enz	-Enz	+Enz	SEM	Level	Enz	Level*Enz
Haematological parameters												
RBC (mm^3x10^6)	2.23	2.35	2.33	2.68	2.48	2.41	2.42	2.62	0.095	NS	NS	NS
HB (g/dl)	11.15	11.65	11.32	12.62	11.82	11.45	11.50	12.27	0.399	NS	NS	NS
PCV (%)	28.27	29.60	29.12	30.95	29.90	28.97	29.32	30.57	0.607	NS	NS	NS
MCV (fl)	127.30	126.07	124.79	115.84	120.79	120.35	121.50	117.2	2.469	NS	NS	NS
MCH (pg)	49.25	49.57	48.55	47.12	47.82	47.45	47.62	47.07	0.860	NS	NS	NS
MCHC (%)	39.39	39.35	38.89	40.74	39.54	39.47	39.19	40.11	0.689	NS	NS	NS
Serum chemistry parameters												
Albumin (g/dL)	0.825	0.775	0.75	0.75	0.80	0.825	0.825	0.85	0.04	NS	NS	NS
Urea (g/dL)	6.25	6.0	6.25	5.25	5.75	5.25	6.25	6.50	0.83	NS	NS	NS
Creatinine (g/dL)	0.125	0.060	0.092	0.092	0.080	0.10	0.117	0.072	0.03	NS	NS	NS
Total protein (g/dL)	3.40	3.22	3.27	3.35	3.15	3.82	3.24	3.82	0.29	NS	NS	NS
AST (IU/L)	249.2	277.2	221.0	243.0	179.0	243.0	233.0	219.7	30.4	NS	NS	NS
ALT (IU/L)	11.50	8.50	7.25	6.75	4.75	8.25	10.0	4.75	1.79	NS	NS	NS
Serum electrolyte parameters												
Sodium (mmol/L)	146.6	146.2	143.2	142.1	144.3	143.9	143.6	140.0	8.77	NS	NS	NS
Potassium (mmol/L)	4.66	5.01	4.59	4.98	5.16	5.0	5.03	4.98	0.55	NS	NS	NS
Chloride (mmol/L)	111.7	111.6	107.5	109	119.4	108.7	110.1	106.6	9.73	NS	NS	NS
Calcium (mg/dL)	7.47	8.10	7.52	7.87	8.15	7.57	8.80	8.15	0.63	NS	NS	NS

SEM: Standard error of mean. NS: Not significant. AST: Aspartate amino transaminase, ALT: Alanine amino-transferase

Table 10: Feed intake, feed cost, revenue and gross margin in US$ per bird

	P. juliflroa pods inclusion (%)	
	Basal	5
Diet enzyme	-Enz	-Enz
Feed intake in kg/bird week 4	1.815	1.812
Feed intake in g/bird week 5	2.822	2.820
Feed intake in g/bird week 6	3.923	3.920
Feed Cost US$ per bird week 4	0.69	0.69
Feed Cost US$ per bird week 5	1.07	1.07
Feed Cost US$ per bird week 6	1.48	1.48
Average weight kg/bird week 4	0.939	0.922
Average weight kg/bird week 5	1.295	1.315
Average weight kg/bird week 6	1.744	1.812
Average Revenue US$/bird week 4	2.93	2.88
Average Revenue US$/bird week 5	4.04	4.10
Average Revenue US$/bird week 6	5.44	5.65
Gross Margin US$/bird week 4	2.24	2.19
Gross Margin US$/bird week 5	2.97	3.04
Gross Margin US$/bird week 6	3.96	4.17
Gross Margin US$/bird/week, week 4	0.56	0.55
Gross Margin US$/bird/week, week 5	0.59	0.61
Gross Margin US$/bird/week, week 6	0.66	0.70

study Tabook *et al*. (2006) noted that there was a decrease in dietary AME when the level of date fibre in the diet increased but the AME value increased with bird age. Hakansson (1973) found that the consumption of metabolizable energy by chickens was equal at similar ages, although the metabolizable energy content in the dry matter of feed varied from 2.81 to 3.47 kcal/g. These results confirmed that the AME in feed is affected by age. Enzyme supplements that hydrolyze non-starch polysaccharides increase the metabolizable energy values of grain legumes in the same way they do in wheat (Choct *et al*., 1995). During different periods of collection in the present study, the AME content of both basal and basal plus 15% *Prosopis juliflora* pods with the enzyme was numerically higher than their counterpart diets without enzyme, which was in line with the finding of Pluske *et al*. (1997) who reported a higher AME content when enzyme was added to diet substituted with 20 and 40% rice bran. Similar to the findings of the current study, Tabook *et al*. (2006), showed that inclusion of the enzyme in the 15% date fibre diet significantly improved AME. Enzymes may produce improvements in AME content and feed conversion ratio in chicken (Bedford, 1994), but the effects are not always

predictable (McCracken *et al*., 1994). Hypothetically, addition of fibre degrading enzyme to poultry diets containing *Prosopis juliflora* pods may improve energy availability for growth and decrease the anti-nutritional effects of non-starch polysaccharides. Diets containing 5, 10 or 15% *Prosopis juliflora* pods did not respond to enzyme supplementation. Although, the average values of AME of the *Prosopis juliflora* pods diets with enzyme were numerically higher than the AME containing diets without enzyme, the differences were not statistically significant as the results were variable. Increased fibre in poultry ration is known to hinder protein and energy digestibility and depresses feed intake as well as enzymatic activity that assist in carbohydrate, protein and fat digestion (Mirnawati *et al*., 2011).

The present study showed an increase in fibre digestibility as the birds age increased, being more marked in diets supplemented with enzyme. This suggests that the low fibre digestibility at a younger age is also more likely to be associated with undeveloped intestinal absorption surface and low pancreas secretion. Traditionally, in most research conducted on poultry feeding, dietary fibre has been considered a diluent of the diet (Rougiere and Carre, 2010); with negative implications in relation to voluntary feed intake and nutrient digestibility (Janssen and Carre, 1985). Consequently, commercial diets, especially those for young broilers, were formulated to contain less than 3% crude fibre. Therefore, fibre digestibility should improve to a greater extent in enzyme-supplemented birds than in those without enzyme supplementation when the absorption surface becomes more developed and secretion of pancreas increased as the bird grows older.

Use of *Propsopis juliflora* pods in poultry feeding gave variable results. Inclusion of *Propsopis juliflora* pods at 5% levels did not cause any negative effect on birds performance. However, the 15% of *Propsopis juliflora* pods substituted the corn in the basal diet in the present study, resulted in a significant depression in broiler performance when compared to basal diet. The reduction in the performance of birds at high level of *Propsopis juliflora* pods inclusion might be due to the negative effects of the high non-starch polysaccharides contents in the ground pods on feed intake as observed in this study. In contrast, Girma *et al*. (2011, 2012) concluded that 20% *Prosopis juliflora* pods can be substituted in broiler and layer rations without negative effect on birds performance despite the effect of high fibre content (6.69% on dry matter basis) of the diet used in their studies. It is well documented that high dietary fibre is often associated with slower rate of passage and may inhibit optimal digestion and through the gut filling effect may lead to a consequent reduction in feed consumption (Thorne *et al*., 1992). A study by Oliveira *et al*. (2001) noted reduction in feed intake of quails when *Prosopis juliflora* pod meal was included at 25% of the ration as compared to the one that did not receive the pod meal. According to Zolfaghari and Harden (1982) and Ravikala *et al*. (1995) the reduction in feed intake when diets contained large proportions of *Propsopis juliflora* pods may be due to the presence of large amounts of the tannins and other phenolic compounds found in the pods which suppressed the appetite of the animals to the diet, or may be due to the high content of fibre in the *Propsopis juliflora* pods that limits nutrient intakes. Similarly, Mahgoub *et al*. (2004) reported a reduction in average daily gain with higher levels of *Prosopis cineraria* at levels of 300 and 450 g/kg, when compared to and 150 g/kg of the diets. Cumulatively, these studies suggest that growth may be adversely affected as the level of *Propsopis juliflora* pods increased. The decline in growth rate could have been due to depression in feed intake that was noticed in previous studies which examined diets containing high levels of *Propsopis juliflora* pods.

Enzyme inclusion in the basal diet in the present study had no significant effect on broiler performance at different ages or during the whole period (0-42 d). There was no improvement in growth rate on chickens fed 5, 10 or 15% *Propsopis juliflora* pods diets supplemented with enzyme in this study, although the overall AME content was improved. Despite the abundance of the agricultural by products in abundance, their inclusion in poultry feeds is limited because of presence of non-starch polysaccharides (NSP), which increase the gut viscosity, slow growth rate and performance of birds (Smits and Annison, 1996). The efficacy of feed enzymes depends on their substrate specificity, activity and stability. Therefore, there is often great difficulty in selecting potentially useful enzymes available in the market (Rotter *et al*., 1990).

Individual organ weights (proventriculus, gizzard, liver, heart, cecum and pancreas) were determined to study the effect of *Propsopis juliflora* pods on the development of digestive tract of birds. The only effect was an increase in the weight of the small intestine (above 10% *Propsopis juliflora* pods), pancreas and cecum (above 15% *Propsopis juliflora* pods). Tabook *et al*. (2006) replaced 5, 10 and 30% of corn with date fibre in the broiler ration and found that weights of liver and heart were similar to those fed 0% date fibre. The high weight of the digestive tract in the present study might be due to the increase in the small intestine weight. The increase in weight of pancreas and caecum at the 15% inclusion of *Prosopis juliflora* pods would have also contributed to increase weight of the digestive tract at this level. The increase in the small intestine weight may be due to the increase in small intestine length or in its absorptive area. This is in agreements with the findings of Brenes *et al*. (1993) who found that feeding diets based on viscous grains resulted in significant increases in the relative size of the digestive tract of broiler chickens. It is

well documented that the birds' intestine responds to the stresses caused by the presences of fibrous substances in the diets in terms of length, weight, absorptive area and rate of turnover of entrocytes (Goodland *et al*., 1989; Savory and Knox, 1991). Similar conclusions have been reported by Johnson *et al*. (1984) who found that viscous gum in rats diets increased stomach size, intestinal length and the rates of enterocytes division by 80%. Similar results have also been reported with rye-fed chicks, from which the rate of enterocytes turnover significantly increased compared to the control (Smithard and Silva, 1995). There was no difference in the weight of total digestive tract of the birds fed basal diets and those fed 5% *Propsopis juliflora* pods containing-diets. Adding 10 and 15% *Propsopis juliflora* pods to the diets caused a significant increase in the total digestive tract weight. There is a positive linear effect of *Propsopis juliflora* pods on small intestine, pancreas and caecum. Similar conclusions were reported by different studies Goodland *et al*. (1989), Savory and Knox (1991) and Tabook *et al*. (2006). The increase in the caeca weight may be due to the presence of the *Propsopis juliflora* pods fibrous materials which passed to the bird's hindgut undigested and provide a suitable environment for microbial growth. This has probably increased the fermentation rate that may lead to an increase in the length of the caeca. The length of the caeca (relative to body weight) are closely positively correlated with dietary fibre levels (Savory and Gentle, 1976). The main function of caeca is to provide an environment for microbial degradation of fibre carbohydrates, protein and uric acid and to absorb products of fermentation, water and electrolytes (McNab, 1973). The pancreas is the primary source of intestinal luminal enzymes (Bedford, 1996). The presence of fibrous materials from the *Propsopis juliflora* pods may stimulate the pancreas to increase its production of luminal enzymes and that may consequently lead to the increase in the pancreas weight. This is in agreement with the results of Ikegami *et al*. (1984) and Tabook *et al*. (2006). Partridge and Wyatt (1995) suggested that pancreatic weight, as a proportion of body weight, is increased in the presences of soluble fibres, implying that feedback mechanisms in the bird's gut stimulate hypertrophy of this organ.

The nature of the feed offered to the birds influences both carcass and meat quality characteristics. Therefore any changes in the feed composition may cause either positive or negative effects on the carcass composition. Round (1992) stated that high nutrient density in broiler's diet produces high carcass fatness, live weight gain and breast meat yield. Inclusion of *Propsopis juliflora* pods with or without enzyme had no significant effect on both carcass composition and meat quality characteristics in the present study. Shear value is an indirect measurement of muscle tenderness. Lower shear values indicate more tender meat (Herring *et al*., 1967). In the current study, a shear force value of 1.7 to 3.7 kg would be considered tender (Lyon and Lyon, 1990). Cooking loss, or weight loss during cooking, is a measurement of water-holding capacity of the muscle. There were no differences between the experimental treatment groups. The numerical distinctions among these means may simply reflect the variable nature of measuring small weight changes in individual muscle samples.

Blood parameters reflect the physiological responsiveness of the birds to its internal and external environment including the type of feed the bird consumed and feeding practices (Esonu *et al*., 2001). In addition, it has been reported that serum biochemical constituents are positively correlated with the quality of the diet (Brown and Clime, 1972; Adeyemi *et al*., 2000). In the current study, the values obtained for all haematological and serological parameters were within the normal range and comparable to those reported in literature for broiler chickens (Campbell *et al*., 2003; Douglas *et al*., 2010). Liver function tests for Glutamic oxaloacetic transaminase (GOT) and Glutamic pyruvic transaminase (GPT) produced similar results in the control birds and the experimental birds and is congruent with the similar reference values reported for chicks by Jerry *et al*. (1997).

Based on the results obtained the economic analysis will therefore focus on the profitability of the two options 5% *Propsopis juliflora* pods diets without enzyme supplementation (-Enz) compared to the Basal without enzyme supplementation (-Enz). Table 10 summarizes the feed costs, revenue and the gross margin per bird according to growth study length period of 4, 5 or 6 weeks. The maximum gross margin was achieved for the 5-Enz experiment and for growth duration of 6 weeks (Fig. 1). The maximum gross margin reaches $ 4.17 for the 5 % (-Enz) versus 3.96 for the Basal (-Enz), with a difference of $ 0.21 per bird. The gain in the gross margin represents 6.4% compared to the Basal (-Enz). Besides, this will represent a lesser use of corn and the use of available resources which otherwise will be lost for the same quality of poultry product. Consequently birds should be slaughtered optimally at the end of week 6 and with a 5% (-Enz) diet rather than the Basal diet. On average the gross margin per bird and per week is the highest for the 5% (-Enz) and for a duration of 6 weeks of breeding. The results are not sensitive to the cost of Propsopis juliflora pods, as an increase by 100% of its cost will keep the same advantage for the 5% (-Enz) compared to the Basal (-Enz) with a benefit of 5.4%.

This study is one of the very few that thoroughly investigated the use of *Prosopis juliflora* pods and the first to investigate its improvement with addition of exogenous enzymes as an energy source to substitute corn in Oman. Inclusion of *Prosopis juliflora* pods at 5%

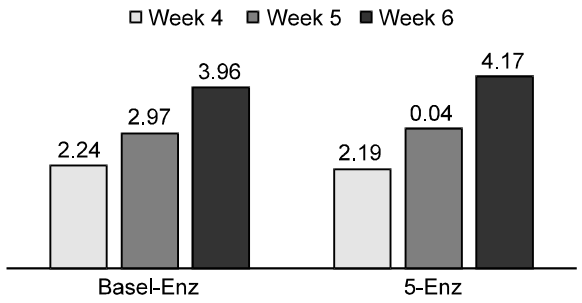

Fig. 1: Gross margin $/bird as a function of growth study

levels did not cause any negative effect on growth, meat quality and sensory characteristics, or affected health status of broiler chickens. Inclusion of *Prosopis juliflora* pods at levels above 10% suppressed daily weight gain, feed intake, feed conversion ratio, fibre digestibility and digestive tract weight. This suggest that *Prosopis juliflora* pods can successfully be used in poultry diets up to 5% levels which will contribute to reduced feed cost for small and medium scale farmers.

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