

# Water intake and excretion of growing she-camels in relation to the type of roughage fed and concentrate

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**Abstract**—The objectives of this study were to evaluate the effect of three roughages (Atriplex, clover hay or rice straw) were fed ad lib with two levels of concentrate (95% and 50% ad lib) on feed intake, water utilization, (water intake and excretion) of growing she-camels. Nine healthy growing she-camels (28-30 months old and 376.3 kg body weight, BW) were housed individually in metabolic cages and randomly allotted to three treatments, three camels each. The experiment lasted for 60 days. Results indicated that limiting concentrate to 50% decreased ( $P < 0.05$ ) ME intake, DCP intake and metabolic water as well as average daily gain, while increased ( $P < 0.05$ ) roughage feed intake, free water intake and total water intake as well as non-excreted water. On the other hand, the effect of roughage type indicated that the Atriplex-fed camels had higher ( $P < 0.05$ ) daily feed intake, water intake and water excretion. The camels fed hay were significantly higher in the metabolic water than those fed Atriplex or rice straw (15.23, 11.06 and 11.95 ml/kg<sup>0.85</sup>, respectively). The camels fed Atriplex recorded significantly ( $P < 0.001$ ) higher free water intake, feed water, total water intake, faecal water output, urinary water excretion and non-excreted water than camels fed hay or straw. The roughage-concentrate interaction was significant ( $P < 0.05$ ) for feed water, faecal water output, urinary water excretion and metabolic water than the other groups. The results indicated that camels fed high concentrate level 95% with clover hay showed the best results concerning by energy intake, body weight gain and feed efficiency. While camels fed Atriplex revealed the highest feed and water intake. The limited concentrate and ad lib roughages offered in camels fed, had significant ( $P < 0.05$ ) increasing free water intake, total water intake, and non-excreted water but decreased metabolic water. There was no observed effect on the amount of faecal water and urinary water excretion.

**Keywords**—growing she-camels, diet selection, feed utilization, growth, water utilization.

## I. INTRODUCTION

Water is an essential nutrient for all animals and total body water is the key component of living ruminants [1]. It is a major constituent of muscles and of meat and the proportion diminishes as the camel grows and gets older. Camel's water requirements depend on age, bodyweight, and disease status, level of exercise, lactation status, temperature, humidity, and dry matter content of the feed consumed. Average size camels require 30–40 liters each per day. Camels on natural range browse and graze derive all, or most of their water, from the plants they eat.

Camels consume less water than sheep and goats. Moreover, they tolerate water deprivation for a long period without any adverse effects on their performance [2,3]. Certain types of desert sheep and goats also, possess the ability to abstain from water for some time, but their resistance is nowhere near that of camels. Urinary water

excretion was less in camels than in sheep [4]. Water deprived camels excreted less urine than those watered daily [5].

Dromedary camels (*Camels dromedarius*) are distributed in arid and semi-arid areas of North Africa, south- East Asia and India [6]; in areas characterized by sparse and unpredictable food and water supplies. They are particularly well adapted to deserts and are better suited to these areas than are cattle, sheep and goats [7, 8]. Their food and water requirements are relatively lower than those of other species and they can extract more energy from the food they consume [9-11]. Their low water requirements allow them to range great distance from water sources in search of food [2]. Herbivores grazing arid rangelands are seasonally challenged with feed and water deficiencies and supplementary feeding is a common practice. To be effective, production wise and economically, the

supplement should complement what the animal gets from the pasture to presumably fulfill its nutritional requirements.

Farid[12] conducted a feeding trials to investigate diet selection, feed intake capacity (FIC) and animal performance when concentrates (corn grains and commercial concentrates mixture) and roughages (Atriplex, clover hay or rice straw) were fed *ad lib* free-choice in a cafeteria feeding system, and also the effect of restricting concentrates offered. The roughages were selected to represent different grazing conditions prevailing in arid rangelands. They indicated that growing camels having free choice to select their diets from both concentrates and roughages were capable of regulating their voluntary food intake predominantly through physiological mechanisms to satisfy energy requirements. This was true for the Atriplex and hay groups but not for the straw group or when concentrates offered was limited

In this regard, the aim of the present experiment was to study the effect of feeding three types of roughages (clover hay, Atriplex and rice straw) with two concentrate levels on the growing she-camel performance and water

utilization.

## II. MATERIALS AND METHODS

### 2.1. Animal management and treatments

Nine healthy growing she-camels were used in the present experiment to study feed intake, digestion and utilization under simulated arid grazing conditions with supplementary feeding. They were 28-30 months old and their live body weight averaged 376.3 kg (range: 356-389 kg). Standard management and health care procedures approved by the Desert Research Centre were followed. Animals were randomly allotted to three *ad lib* feeding treatments of three roughage types species (three she-camels in each) to represent the different grazing conditions prevailing in arid rangelands. Egyptian clover hay to represent optimum grazing conditions, rice straw to represent dry season grazing and *Atriplex halimus* to represent arid rangelands dominated by halophytes were the roughages that offered to animals. In addition the concentrates used were corn grains and cottonseed meal at two levels 95 and 50% of *ad lib* as recommended by Farid[12]. Proximate composition of the feed ingredients is presented in Table (1).

Table 1. Dry matter, total protein and crude fibres intakes (g/day/kg 0.73) at 100% and 50% *ad lib* concentrates used to calculate dry matter allowances for the present experiment [12].

Feed ingredients	Dry matter		Total protein		Crude fibres	
	100%	50%	100%	50%	100%	50%
<b>Hay group</b>						
Clover hay	22.45	38.11	3.20	5.43	7.68	13.05
Corn grains	43.17	21.78	4.64	2.34	1.63	0.82
Cottonseed meal	18.19	9.05	2.88	1.43	3.51	1.75
Total	83.81	68.94	10.72	9.20	12.82	15.62
<b>Atriplex group</b>						
<i>Atriplex halimus</i>	37.16	72.64	4.35	8.50	10.64	20.79
Corn grains	45.02	23.90	4.84	2.57	1.70	0.90
Cottonseed meal	11.03	5.66	1.75	0.90	2.13	1.09
Total	93.21	102.20	10.94	11.97	14.47	22.78
<b>Straw group</b>						
Rice straw	14.97	27.30	0.68	1.24	4.32	7.88
Corn grains	44.30	21.85	4.77	2.35	1.67	0.82
Cottonseed meal	13.88	6.85	2.20	1.08	2.68	1.32
Total	73.15	56.00	7.65	4.67	8.67	10.02

The camels were housed individually in metabolism

cages (1.3 x 3.0 m), designed for the separate collection of

faeces and urine, for the duration of the experiment which lasted 60 days in two periods, 30 days each. The two consecutive experimental periods represented feeding levels of concentrate 95% and 50%, respectively. Those were, respectively, of average *ad lib* roughage and concentrate intakes calculated, per unit metabolic weight ( $\text{kg}^{0.75}$ ), from a previous experiment [12] and summarized in Table (2).

Dry matter intake reported in Table (1) or the present experiment differs because of occasional incomplete consumption of offered rations.

Feeds were offered twice daily at 8:00 and 16:00 hours. Refusals, if any, were weighed the following morning and intake was recorded for each animal. Water was made available free choice once daily at the morning feeding time and water intake was recorded daily for each animal. Animals were weighted periodically after overnight fast and on two consecutive days.

## 2.2. Digestion trials

Each of the two consecutive digestion and nitrogen balance trials lasted 30 days. Animals were introduced to the respective diets for 15 days, followed by an 8-day preliminary period and a 7-day collection period. During the collection period, food refusals (if any), feces and urine were quantitatively collected once daily before feeding. Composite dried samples of feces were ground for laboratory analysis. Urine was collected in containers

containing 50 ml of 50%  $\text{H}_2\text{SO}_4$  and samples were taken daily for each animal and frozen until later chemical analysis.

## 2.3. Analytical procedures

Chemical composition of the experimental rations, feed refusals, feces and urinary nitrogen were determined according to procedures of [13].

## 2.4. Statistical analysis

Main effects and interactions were evaluated using the GLM repeated-measures analysis of variance procedures of the NCSS statistical package [14]. The type of roughage and concentrate levels were the independent variables, and concentrate levels were repeated within roughages. Newman-Keuls multiple comparison test was applied to the means of the main effects, i.e. type of roughage, R-means, and level of concentrates, C-means.

# III. RESULTS AND DISCUSSIONS

## 3. 1. Chemical composition of feed ingredients

Proximate analysis of the three roughages are presented in Table (2) showed that Clover hay was higher in organic matter, crude protein, crude fiber, ether extract and Atriplex was higher in ash, while the straw was the least in these components. These proximate analysis values of feed ingredients used in this experiment were in agreement to previous investigations [12, 15].

Table 2: Proximate composition of feed ingredients, % DM basis

Proximate constituents	Egyptian Clover hay	Rice Straw	Atriplexh alimus <sup>2</sup>	Corn grains	Cottonseed meal <sup>1</sup>
Dry matter	86.08	87.43	34.98	86.65	90.88
Ash	13.35	21.68	25.37	1.71	24.73
Organic matter	86.65	78.32	74.63	98.29	75.27
Total (crude) protein	14.26	4.55	11.70	10.76	15.84
Crude fibers	34.23	28.86	28.62	3.77	19.30
Ether extract	4.40	2.52	2.94	3.92	10.86
N-free extract	33.76	42.39	31.37	79.84	29.27

<sup>1</sup>Un-decorticated, heat treated and mechanically pressed CSM, produced in a traditional mill,

<sup>2</sup>Leaves and succulent branches typically consumed by grazing animals,

## 3.2. Feed intake

Results indicated that decreasing the level of concentrate from 95% to 50% of *ad lib* intake decreased ( $P<0.0001$ ) total dry matter intake (DMI). However, the intake of the three types of roughages (hay, Atriplex and

straw) as a percentage of DMI increased ( $p<0.001$ ). At the same trend, Jakhmola and Roy [16] reported that when growing camels were fed *ad lib* on a local Indian roughage (moth chara) with three levels of protein concentrate supplementation, (LPN), 18 (MPN) and 28 g DM/d/Kg<sup>0.75</sup>

(HPN), their roughage intake decreased significantly by 22% and 12% for camel groups fed high (HPN) and medium (MPN) levels of protein concentrate, respectively and compared less than their mates fed low level (LPN) of concentrate. They indicated that this decrease may be due to changes in the rumen fermentation pattern. Whereas feeding low levels of concentrates stimulated cellulolytic fermentation in the rumen, high levels of concentrates tend to change fermentation pattern from typical cellulolytic to amylolytic. Thus, rumen retention time of roughage might have been increased, thus, reducing the intake of roughages. Also, the present results of the linear relationship between increasing the level of concentrate and total DMI were in agreement with that trends of total DM intake were reported by other investigations [17-20]. However, concentrate supplementation reduced roughage intake even though total DMI increased [21, 22]. Also, Farid [12] reported that increasing concentrate levels caused a decline in roughage intake and increased total DMI in camels fed hay or straw, but when concentrate level were reduced to 50% of *ad libitum* intake, roughage intake increased while total DMI decreased.

The type of roughage significantly ( $P < 0.001$ ) affected DMI. Growing she-camels fed Atriplex recorded greater ( $P < 0.05$ ) DMI and roughage as a % of DMI (Table 3) than strawfed camels group which had the least DMI value and those fed hay were intermediate. The roughage-concentrate interaction was not significant.

On the other hand, it was noticeable that when the level of concentrate decreased to 50% of *ad lib*, growing she-camels group fed Atriplex recorded higher ( $P < 0.05$ ) total DMI and roughage (% of DMI) than their mates fed clover hay or rice straw, respectively. This may be due to the positive response of camels to Atriplex feeding which is attributed to two principal factors [23]. First, camels appear to need more salt, probably more than other herbivores, which is in higher proportion in this plant. This fact was demonstrated previously by Chamberlain [24] who demonstrated that camels require six to eight times the amount of salt required by other livestock, and camels without regular access to salty feed require about 140 g of salt per day. So, these finding explain the higher ( $P < 0.05$ ) intake of DM, when camels fed Atriplex in comparison to their mates fed either hay or straw. Second, in comparison to bovines, camel saliva contains a varying content of high molecular weight mucin-glycoprotein (MGP) that confers protection to the mucosa of the digestive tract from

mechanical injuries and fixes the plant tannins preventing their negative effects on protein metabolism in the rumen [25]. In addition, Atriplex being a lush green plant was more palatable and preferred by camels in comparison to the dry long clover hay and rice straw. In the straw fed group, the poor digestibility and low nutritive value did limit the VFI and adversely affected animal performance [26].

Data of metabolize energy (ME, kcal/day/kg<sup>0.73</sup>) intake show almost the same significant trend of the impact of the type of roughage and concentrate supplementation level on dry matter intake (Table 3). On the other hand, data of digested crude protein intake (DCP, g/day/kg<sup>0.73</sup>) was affected ( $P < 0.001$ ) by changing the type of roughage. Whereas, growing she-camel fed Atriplex recorded comparable DCP intake value to their mates fed clover hay and significantly higher about twice times that of those fed rice straw. This was mainly due to the higher CP% content of clover hay and Atriplex (Table 1) [27].

### 3.3. She-camel live body weight, daily gain and feed efficiency

Live body weights of growing she-camels were not significantly affected by changing the level of concentrate supplementation or the type of roughage (Table 3). Average daily gains (g/day) of camels fed hay and Atriplex were higher ( $P < 0.001$ ) than those of their mates fed rice straw with limiting concentrate offered to 50%.

These results indicated that ADG was affected ( $P < 0.001$ ) by the type of roughages. In this respect, Kamoun [28] found that the ADG ranged from 326 to 525 g/d in one-year old camels fed on *ad libitum* hay and hay plus concentrate (80% wheat bran). While Etman [29] found that the ADG was 412 g for camels fed on berseem or hay plus concentrate, and it was 386 g/d for camels fed on wheat straw plus concentrate. However, Faye [18] indicated that ADG was 550 g/d for concentrate-supplemented camels and 570 g/d for concentrate plus mineral supplemented camels. Kamoun [30, 31] demonstrated that the daily gain of the growing camels at the period from five to ten months of age was 605 g/d and gust 280 g with the diet having 22% protein. Khanna [32] reported that values of daily gain of Kutchi and Bikaneri camels were 800 and 749 g, respectively, up to three months of age.

Table 3: Nutritional and performance parameters of growing she-camels.

Concentrate level [C]	Roughage, <i>ad lib</i> [R]			C-means	Repeated-measures ANOVA ( <i>p</i> value)		
	Hay	Atriplex	Straw		R	C	RxC
<b>Live body weight, kg</b>							
95% <i>ad lib</i>	389.17	355.83	383.83	376.28	0.2245	0.0000	0.0283
50% <i>ad lib</i>	424.83	396.33	402.67	407.94			
R-means	407.00	367.08	393.25				
± SEM		11.132		1.775			
<b>Average daily gain, g/day</b>							
95% <i>ad lib</i>	911.46	760.42	671.88	781.25 <sup>b</sup>	0.0018	0.0006	0.3437
50% <i>ad lib</i>	473.12	355.56	-10.76	272.74 <sup>a</sup>			
R-means	692.29 <sup>b</sup>	557.99 <sup>b</sup>	330.56 <sup>a</sup>				
± SEM		39.483		54.655			
<b>Dry matter intake (DMI), g/day/kg<sup>0.73</sup></b>							
95% <i>ad lib</i>	77.14	81.11	71.73	76.66 <sup>b</sup>	0.0192	0.0001	0.4289
50% <i>ad lib</i>	62.71	70.10	55.45	62.75 <sup>a</sup>			
R-means	69.92 <sup>ab</sup>	75.60 <sup>b</sup>	63.59 <sup>a</sup>				
± SEM		2.098		1.103			
<b>Roughage, %DMI</b>							
95% <i>ad lib</i>	32.22	39.44	27.92	33.19 <sup>a</sup>	0.0009	0.0000	0.3712
50% <i>ad lib</i>	56.89	60.47	51.73	56.36 <sup>b</sup>			
R-means	44.55 <sup>b</sup>	49.95 <sup>c</sup>	39.83 <sup>a</sup>				
± SEM		0.961		0.715			
<b>ME intake, kcal/day/kg<sup>0.73</sup></b>							
95% <i>ad lib</i>	218.3	168.4	178.2	188.3 <sup>b</sup>	0.0015	0.0000	0.9184
50% <i>ad lib</i>	148.0	90.9	104.3	114.4 <sup>a</sup>			
R-means	183.2 <sup>b</sup>	129.6 <sup>a</sup>	141.4 <sup>a</sup>				
± SEM		5.837		4.982			
<b>DCP intake, g/day/kg<sup>0.73</sup></b>							
95% <i>ad lib</i>	6.873	6.857	4.986	6.239 <sup>b</sup>	0.0002	0.0003	0.0206
50% <i>ad lib</i>	5.519	6.182	2.364	4.688 <sup>a</sup>			
R-means	6.196 <sup>b</sup>	6.519 <sup>b</sup>	3.675 <sup>a</sup>				
± SEM		0.2187		0.1432			
<b>Efficiency of ME utilization for gain, kcal/g</b>							
95% <i>ad lib</i>	19.88	17.66	21.66	19.37	0.3377	0.5161	0.3225
50% <i>ad lib</i>	27.33	34.51	-55.24	2.20			
R-means	23.61	26.08	-16.79				
± SEM		21.045		17.976			
<b>Efficiency of DCP utilization for gain, g/g</b>							
95% <i>ad lib</i>	0.630	0.719	0.609	0.653	0.1497	0.9497	0.2091
50% <i>ad lib</i>	1.019	2.406	-1.322	0.701			
R-means	0.825	1.653	-0.356				
± SEM		0.5946		0.5221			

<sup>a-b-c</sup> means within a main effect, C-means or R-means, not sharing a superscript were significantly ( $P < 0.05$ ) different according to Newman-Keuls multiple range test.

Decreasing the level of concentrate supplementation from 95% to 50% resulted in decreasing ( $P < 0.001$ ) the ADG by 65% (range from 781.25 to 272.74g/day). This result is in agreement with that reported by Farid [12]. They decreased concentrate supplementation from *ad lib* to 50% and found ADG to decrease by 73%. The same trend was reported by Jakhmola and Roy [16], for growing camels. It is noticeable that Atriplex and hay

feeding with *ad lib* concentrate supplementation or when limited to 50% of *ad lib*, recorded the highest DMI in comparison to straw-feeding.

Irrespective of the level of concentrate offered, hay and Atriplex feeding promoted better intake, ME and DCP than straw resulting in the highest observed ADG. Similar results were reported earlier by Shawket [23] who



indicated that growing camels fed Atriplex supplemented with crushed barley grains (100% of their growth energy requirements).

Efficiency utilization of ME for gain (kcal/g) or DCP utilization for gain (g/g) was not affected by changing

the type of roughage or the level of concentrate. The roughage-concentrate interaction also showed no effect.

### 3.4. Water intake and excretion

Data of average water intake and excretion (ml/day/kg<sup>0.82</sup>) are present in Table (4) and Figure (1).

Table 4. Water intake and excretion, ml/day/kg<sup>0.82</sup>.

Concentrate level [C]	Roughage, <i>ad lib</i> [R]			C-means	Repeated-measures ANOVA ( <i>p</i> value)		
	Hay	Atriplex	Straw		R	C	RxC
<b>Free water intake</b>							
95% ad lib	111.17	144.02	113.39	122.86 <sup>a</sup>	0.0014	0.0000	0.1285
50% ad lib	199.16	247.08	217.86	221.37 <sup>b</sup>			
R-means	155.17 <sup>a</sup>	195.55 <sup>b</sup>	165.63 <sup>a</sup>				
± SEM		4.297		2.173			
<b>Feed water</b>							
95% ad lib	6.74	40.05	6.04	17.61	0.0000	0.0618	0.0089
50% ad lib	5.57	50.64	4.65	20.29			
R-means	6.15 <sup>a</sup>	45.35 <sup>b</sup>	5.34 <sup>a</sup>				
± SEM		1.254		0.827			
<b>Metabolic water</b>							
95% ad lib	18.06	14.05	14.48	15.65 <sup>b</sup>	0.0013	0.0000	0.9733
50% ad lib	12.40	8.07	9.06	9.84 <sup>a</sup>			
R-means	15.23 <sup>b</sup>	11.06 <sup>a</sup>	11.95 <sup>a</sup>				
± SEM		0.444		0.394			
<b>Total water intake</b>							
95% ad lib	135.96	198.12	134.27	156.12 <sup>a</sup>	0.0000	0.0000	0.1259
50% ad lib	217.13	305.80	231.58	251.50 <sup>b</sup>			
R-means	176.55 <sup>a</sup>	251.96 <sup>b</sup>	182.92 <sup>a</sup>				
± SEM		4.607		3.157			
<b>Faecal water output</b>							
95% ad lib	16.26	28.49	20.62	21.79	0.0099	0.5236	0.0142
50% ad lib	13.05	37.04	17.83	22.64			
R-means	14.65 <sup>a</sup>	32.76 <sup>b</sup>	19.22 <sup>a</sup>				
± SEM		2.844		0.889			
<b>Urinary water excretion</b>							
95% ad lib	43.91	33.63	15.49	31.01	0.0084	0.9156	0.0411
50% ad lib	24.06	50.48	19.99	31.05			
R-means	33.99 <sup>ab</sup>	42.05 <sup>b</sup>	17.74 <sup>a</sup>				
± SEM		3.611		3.194			
<b>Non-excreted water</b>							
95% ad lib	75.79	136.00	98.16	103.32 <sup>a</sup>	0.0052	0.0000	0.4814
50% ad lib	180.02	218.28	193.75	197.35 <sup>b</sup>			
R-means	127.91 <sup>a</sup>	177.14 <sup>b</sup>	145.96 <sup>a</sup>				
± SEM		6.575		4.960			

<sup>a,b,c</sup> means within a main effect, C-means or R-means, not sharing a superscript were significantly ( $P < 0.05$ ) different according to Newman-Keuls multiple range test.

At reducing level of concentrates from 95% to 50% of respective *ad lib* intake, the free water intake, total water intake and non-excreted water increased ( $P < 0.001$ ), and the metabolic water intake decreased ( $P < 0.001$ ). Meanwhile, the feed water, fecal water output and urinary

water excretion were not significantly affected. On the other hand, the roughage type significantly affected the water intake and excretion. Camels fed *ad lib* Atriplex recorded the highest ( $P < 0.001$ ) free water intake, feed water, total water intake, fecal water output, urinary water

excretion, and non-excreted water than their mates fed *ad lib* clover hay or rice straw which showed comparable values. She-camels fed Atriplex or rice straw recorded the lower ( $P < 0.001$ ) metabolic water values than their mates fed the hay. The roughage-concentrate interaction significantly ( $P < 0.05$ ) affect feed water, fecal water output and urinary water excretion, while free water intake, metabolic water, total water intake and had no significant effect on non-excreted water.

Camels fed Atriplex with its high content of sodium chloride and soluble proteins might have resulted in increased rumen osmolality and ammonia concentration, both known to negatively affect voluntary food intake (VFI) [33, 34]. However, since fresh drinking water was freely available, along with that available from the lush plant, it seems that the anticipated negative effect on VFI was counter-balanced. Similar results were reported in previous investigations [35, 36].

These results were in agreement with the findings of other investigators [37, 38] who indicated that increasing salinity of drinking water increased water excretion in urine than in faeces. Ahmed [39] pointed out that increasing water excretion through the urinary pathway is believed to be an adaptive mechanism assisting the animal in getting rid of excess salts and maintain osmolality of food and other body fluids. She-camel group fed Atriplex recorded higher ( $P < 0.05$ ) non-excreted water ( $\text{ml/day/kg w}^{0.82}$ ) values than those of camels fed on straw or hay. These results indicated that camels' kidneys seem to be better adapted to handling salt load especially when they fed on halophytic plants [40]. The roughage-concentrate interaction was significant ( $P < 0.05$ ) in affecting feed water, faecal water output and urinary water excretion, while no significant effect on other water parameter was detected.

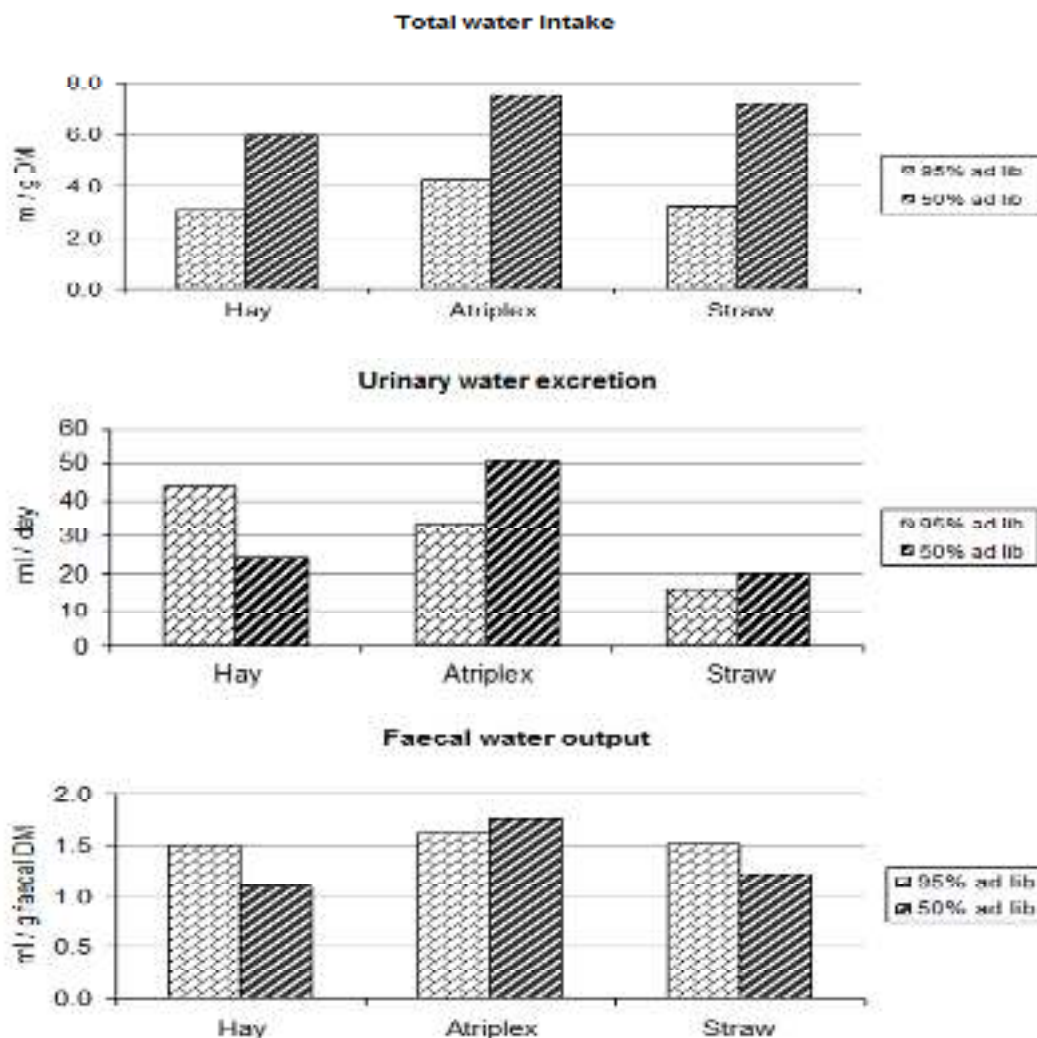


Fig.1: Total water intake and faecal water output as a function of dry matter intake and excretion.

Limiting the concentrate level from 95 to 50% significantly decreased feed water, metabolic water, fecal water and urinary water in relation to total water intake (TWI). On other hand, free water intake and non-excreted water in relation to TWI increased (Table 5). This may be

due to decreasing the concentrate level, increased roughage percentage of DMI which need to increase water intake (Table 4) for its rumen fermentation and digestion and this reflect on non-excreted water values.

Table 5. Water intake and excretion in relation to total water intake (TWI), %.

Concentrate level [C]	Roughage, <i>ad lib</i> [R]			C-means	Repeated-measures ANOVA ( <i>p value</i> )		
	Hay	Atriplex	Straw		R	C	RxC
<b>Free water intake, %TWI</b>							
95% ad lib	81.73	72.80	84.83	79.66 <sup>a</sup>	0.0000	0.0000	0.2247
50% ad lib	91.71	80.80	94.07	88.86 <sup>b</sup>			
R-means	86.72 <sup>b</sup>	76.80 <sup>a</sup>	89.25 <sup>c</sup>				
± SEM		0.568		0.312			
<b>Feed water, %TWI</b>							
95% ad lib	4.96	20.14	4.50	9.86 <sup>b</sup>	0.0000	0.0001	0.2509
50% ad lib	2.56	16.56	2.01	7.05 <sup>a</sup>			
R-means	3.76 <sup>a</sup>	18.35 <sup>b</sup>	3.26 <sup>a</sup>				
± SEM		0.435		0.203			
<b>Metabolic water, %TWI</b>							
95% ad lib	13.31	7.06	11.07	10.48 <sup>b</sup>	0.0001	0.0000	0.0019
50% ad lib	5.72	2.64	3.92	4.09 <sup>a</sup>			
R-means	9.52 <sup>c</sup>	4.85 <sup>a</sup>	7.49 <sup>b</sup>				
± SEM		0.274		0.152			
<b>Faecal water, %TWI</b>							
95% ad lib	11.82	14.51	15.35	13.90 <sup>b</sup>	0.1611	0.0017	0.1703
50% ad lib	5.97	12.11	7.75	8.61 <sup>a</sup>			
R-means	8.90 <sup>a</sup>	13.31 <sup>a</sup>	11.55 <sup>a</sup>				
± SEM		1.401		0.695			
<b>Urinary water, %TWI</b>							
95% ad lib	33.03	17.02	11.51	20.52 <sup>a</sup>	0.0828	0.545	0.0909
50% ad lib	11.12	16.52	8.64	12.09 <sup>a</sup>			
R-means	22.07 <sup>a</sup>	16.77 <sup>a</sup>	10.07 <sup>a</sup>				
± SEM		3.051		2.500			
<b>Non-excreted water, %TWI</b>							
95% ad lib	55.15	68.46	73.14	65.58 <sup>a</sup>	0.1177	0.0089	0.0733
50% ad lib	82.90	71.38	83.62	79.30 <sup>b</sup>			
R-means	69.03 <sup>a</sup>	69.92 <sup>a</sup>	78.38 <sup>a</sup>				
± SEM		2.920		2.547			

<sup>a,b,c</sup> means within a main effect, C-means or R-means, not sharing a superscript were significantly ( $P < 0.05$ ) different according to Newman-Keuls multiple range test.

The type of roughage affected ( $P < 0.001$ ) free water intake as % of TWI. Straw-fed camels recorded the higher value followed by the hay-fed camels and then the Atriplex-fed camels had the least. This result may be due to Atriplex fed camel group which drank greater ( $P < 0.05$ ) amount of water than their mates fed straw or hay (Table 4). Also, Atriplex-fed camels' recorded significantly higher feed water % TWI than those fed hay and straw-fed due to that Atriplex had higher moisture content about 65% (Table 2). Camels group fed hay had higher ( $P < 0.001$ ) value of

metabolic water as % of TWI, while the Atriplex-fed camels were the least and those fed straw were intermediate. As mentioned earlier, camels fed hay had higher ( $P < 0.001$ ) metabolic water (ml/day/kg<sup>0.82</sup>) and recorded the lowest ( $P < 0.001$ ) value of TWI compared to their mates fed Atriplex which recorded the highest value of TWI. Fecal water, urinary water and non-excreted water in relation to TWI were not affected significantly by the type of roughage.



### 3.5. Water intake and non-excreted water in relation to gross energy intake

Data of free water intake, total water intake and non-excreted water (ml/kcal GE intake) in relation to gross energy intake in Table (6) and Figure(2)

Table 6. Water intake and non-excreted water in relation to gross energy intake

Concentrate level [C]	Roughage, <i>ad lib</i> [R]			C-means	Repeated-measures ANOVA ( <i>p value</i> )		
	Hay	Atriplex	Straw		R	C	RxC
Free water intake, ml/kcal GE intake							
95% ad lib	0.570	0.752	0.650	0.657 <sup>a</sup>	0.0038	0.0000	0.0014
50% ad lib	1.290	1.556	1.697	1.514 <sup>b</sup>			
R-means	0.930 <sup>a</sup>	1.154 <sup>b</sup>	1.173 <sup>b</sup>				
± SEM		0.0336		0.0142			
Total water intake, ml/kcal GE intake							
95% ad lib	0.697	1.032	0.769	0.832 <sup>a</sup>	0.0003	0.0000	0.0033
50% ad lib	1.406	1.925	1.804	1.712 <sup>b</sup>			
R-means	1.052 <sup>a</sup>	1.478 <sup>c</sup>	1.286 <sup>b</sup>				
± SEM		0.326		0.0161			
Non-excreted water, ml/kcal GE intake							
95% ad lib	0.386	0.708	0.562	0.552 <sup>a</sup>	0.0025	0.0000	0.0814
50% ad lib	1.166	1.374	1.509	1.360 <sup>b</sup>			
R-means	0.776 <sup>a</sup>	1.041 <sup>b</sup>	1.036 <sup>b</sup>				
± SEM		0.0349		0.029			

<sup>a,b,c</sup> means within a main effect, C-means or R-means, not sharing a superscript were significantly ( $P < 0.05$ ) different according to Newman-Keuls multiple range test.

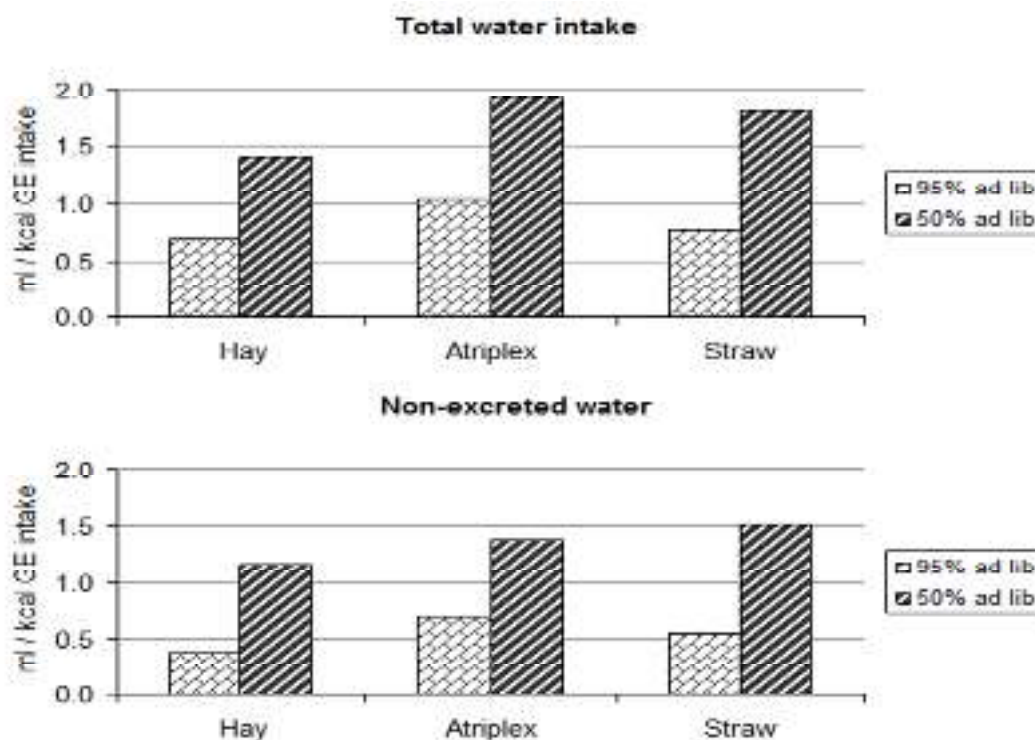


Fig. 2: Total water intake and non-excreted water as a function of gross energy intake.

### 3.6. Water intake and faecal water excretion in relation to dry matter, ml/g DM

The data in Table (7) indicated that limiting feed concentrate level from 95 to 50% increased ( $P < 0.05$ ) free

water intake, and total water intake relation to dry matter intake (ml/g DM). This may be due to that limiting diet concentrate level increased the amount of roughage consumption as a percentage of total dry matter intakes (Table 3). Whereas previously, Greg [41] indicated that feeds high in crude fiber, such as roughages will require more water for ingestion than feeds low in crude fiber such as barley and corn. Type of roughage also significantly affected free water intake, and total water intake in relation to dry matter intake (ml/g DM) which in agreement with results of goats fed different types of roughages [42]. Growing camels group fed hay recorded the lowest ( $P < 0.05$ ) values and their mates group fed Atriplex had higher values than those fed straw. This result is due to the higher values of free water intake and total water intake of growing camel group fed Atriplex than their mate groups fed hay and straw by about 25, 18, 43 and 38%, respectively. In this context, Greg [41] reported that

increasing the salt concentration level of the diet stimulated water intake in all species because of the increase in urine volume necessary for excretion of salt.

Limiting the diet concentrate level decreased fecal water in relation to fecal dry matter (ml/g fecal DM). This result made clear that the fresh fecal mass weight was higher with its moisture content which resulting in low fecal dry matter due to that high concentrate diets content result in more digestible and nutritious.

The type of roughages had a significant effect on fecal water in relation to its dry matter. The atriplex-fed camels had the highest values in total water intake and fecal water in relation to dry matter faecal, while the hay-fed camels had the lowest values and those fed on straw were intermediate. The roughage-concentrate interaction was significant.

Table 7. Water intake and faecal water excretion in relation to dry matter, ml/g DM

Concentrate level [C]	Roughage, <i>ad lib</i> [R]			C-means	Repeated-measures ANOVA ( <i>p value</i> )		
	Hay	Atriplex	Straw		R	C	RxC
<b>Free water intake, ml/g DMI</b>							
95% ad lib	2.479	3.062	2.714	2.752 <sup>a</sup>	0.0162	0.0000	0.0019
50% ad lib	5.490	6.056	6.741	6.096 <sup>b</sup>			
R-means	3.984 <sup>a</sup>	4.559 <sup>b</sup>	4.728 <sup>b</sup>				
± SEM		0.1311		0.0525			
<b>Total water intake, ml/g DMI</b>							
95% ad lib	3.032	4.200	3.214	3.482 <sup>a</sup>	0.0009	0.0000	0.0072
50% ad lib	5.986	7.495	7.165	6.882 <sup>b</sup>			
R-means	4.509 <sup>a</sup>	5.848 <sup>c</sup>	5.190 <sup>b</sup>				
± SEM		0.1265		0.0585			
<b>Faecal water, ml/g faecal DM</b>							
95% ad lib	1.495	1.619	1.510	1.541 <sup>b</sup>	0.0394	0.0014	0.0015
50% ad lib	1.086	1.753	1.198	1.346 <sup>a</sup>			
R-means	1.290 <sup>a</sup>	1.686 <sup>b</sup>	1.354 <sup>a</sup>				
± SEM		0.0880		0.0246			

<sup>a,b,c</sup> means within a main effect, C-means or R-means, not sharing a superscript were significantly ( $P < 0.05$ ) different according to Newman-Keuls multiple range test.

#### IV. CONCLUSION

The results indicated that camels fed high concentrate level 95% with clover hay showed the best results with respect

to energy intake, body weight gain and feed efficiency, while those fed Atriplex revealed the highest feed and water intake. Feeding limited concentrate and *ad lib* roughages resulted in significant ( $P < 0.05$ ) increased free

water intake, total water intake, and non-excreted water but decreased metabolic water. There was no effect on the amount of faecal water and urinary water excretion. Therefore, camels can be successfully adapted to feeding *Atriplex Halimus* (saltbush plant) with no negative impact on their performance.

## V. REFERENCES

- [1] Panaretto, B. A. and A. R. Till, 1963. Body composition in vivo. The composition of mature goats and its relationship to the antipyrine, tritiated water and N- acetyl-4 amino-antipyrine spaces. Australian Journal of Agricultural Research, 14: 926-943.
- [2] Schmidt-Nielsen, K. (1964): The Camel In: Desert Animals: physiological problems of heat and water. Clarendon Press, Oxford. P. 277.
- [3] Farid, M.F.A., Sooud, A. E. O., and Shawket, S.M. (1985): Water intake and excretion of camels and sheep in relation to diet characteristics and water deprivation. 3rd. AAP. Anim. Sci. Cong. May, Seoul, Korea. PP. 799-857.
- [4] Macfarlane, W.V., Morris, R. J. H., and Howard, B. (1963): Turnover and distribution of water in desert camels, sheep, cattle and kangaroos, Nature, London. 197: 270.
- [5] Kandil, H.M. (1984). Studies on camel's nutrition. Ph. D. Thesis, Fac. of Agric., Ain Shams Univ., Egypt.
- [6] Mason, T.L. (1979). The camel in Australia. Melbourne University press. Melbourne Australia.
- [7] McKnight, T.L. (1969). The camel in Australia, 154 pp. (Melbourne University Press, Melbourne Australia (154p).
- [8] Wilson, R.T. (1984). The camel. Harlow, Essex, Longman Group Ltd., UK.
- [9] Macfarlane, W.V., B. Howard, G. M. O Maloly, and D. Hop craft. (1972). Tritiated water in field studies of ruminant metabolism in Africa. In isotope studies on the physiology of domestic animals. Pp. 83-94. International Atomic Energy Authority. Vienna.
- [10] Farid, M.F.A., S.M. Shawket, and M.H.A. Abdel-Rahman, (1979). Observations on the nutrition of camels and sheep under stress. In: Camels. IFS Symp., Sudan, 125-170.
- [11] Yagil, R.T. (1981). Camel milk and camel products. Report to the Food and Agriculture Organization. Rome.
- [12] Farid, M.F.A., A.M. Abdel-Wahed, Safinaz M. Shawket and N.I. Hassan. (2010). Diet Selection, feed Intake capacity and performance of growing female camels: Effects of type of roughage and level of concentrates offered. J. American Sci., 6: 317-326.
- [13] AOAC – Association of Official Agricultural Chemists. (1990). Official Methods of Analysis, 15th edition. AOAC, Washington DC.
- [14] Hintze, (2007). NCSS. Kaysville, Utah, U.S.A.
- [15] Abdel-Wahed, A. M. (2014). Effect of type of roughage of concentrate supplements on feed digestion and utilization in growing female dromedary camels. Journal of American Science 2014;10 (6): 198-206.
- [16] Jakhmola, R.C. and A.K. Roy. (1992). Effect of supplementation of concentrate on body weight gain and serum constituents in camel. Indian, J. Anim. Sci. 62:8, 782-784.
- [17] Tan, P.V. and M.J. Bryant. (1991). The effects of dietary supplements of fish meal on the voluntary food intake of store lambs. Anim. Prod., 52: 271.
- [18] Faye, B., G. Saint-Martin, R. Cherrier, and A. Ruffa. (1992.) The influence of high dietary protein, energy and mineral intake on deficient young Camel (*Camelus dromedarius*). Changes in metabolic profiles and growth performance. Comp. Bioch. and Physiol. A Comp. Physiol., 102:2, 409 – 416.
- [19] Fahmy, A.A. (1993). Some factors affecting the nutritional performance of camels under desert conditions. M.Sc. Thesis, Al-Azhar Univ. Fac. Agric., Cairo, Egypt.
- [20] Migwi, P.K., I. Godwin and J.V. Nolan. (2006). The effect of nitrogen, protein and energy supplementation on voluntary intake in sheep fed low quality roughage. Proceedings of the 10th KARI biennial scientific conference, Vol 1, 12-17 November 2006, Nairobi, Kenya.
- [21] Jabbar, M.A. and M.I. Anjum. (2008). Effect of diets with different forage to concentrate ratio for fattening of Lohi lambs. Pak. Vet. J., 28: 150-152.
- [22] Shawket, S. M., M. H. Ahmed, H.S.Ziwal, A. M. Nour and A.M. Abd EL-Wahed. (2007). Camel's growth performance response to dietary protein levels. Egyptian Journal of Nutrition and Feeds, 10: 477- 489.
- [23] Shawket, S. M., K.M. Youssef and M. H. Ahmed. (2010). Comparative evaluation of Egyptian clover and *Atriplex halimus* diets for growth and milk production in camel. Animal Science Reporter, vol. 4: 9-21.
- [24] Chamberlain, A. (1989). Milk production in the tropics. Intermediate Tropical Agricultural Series 13, Camels, 202-210.
- [25] Schmidt-Witty, U., R. Kownatki, M. Lechner-Doll, and M. L. Enss. (1994). Binding capacity of camel saliva mucins for tannic acid. J. of Camel Practice and Research, December, 121.
- [26] Cianci, D., L. Goio, A.M. Hashi, S. Pastorelli, M. Kamoun, G.B. Liponi and M. Orlandi. (2004). Feed intake and digestibility in camels fed wheat straw and Meadow hay. J. Camel Science. 1: 52-56.
- [27] Shawket, S. M., H.S.Ziwal, M. H. Ahmed, A. M. Nour and A.M. Abdel-Wahed. (2005). Camel's performance response to dietary protein level under semi-arid conditions. Egyptian Journal of Nutrition and Feeds, 8: 211- 223.
- [28] Kamoun, M., P. Girard, and R. Bergaoui. (1989). Feeding and growth of the dromedary. Effect of concentrate feeding on dry matter intake and growth of camels in Tunisia Revue, d'Elevage et de Med. Vet. Des Pays Tropicaux. 42, 89-94.
- [29] Etman, A.H.M. (1997). Effect of nutrition on the productive and reproductive efficiency of one humped camels. Ph. D. Fac. Agric. Al-Azhar Univ. Egypt.
- [30] Kamoun, M. (1993). Reproduction and production of Maghrabi dromedaries kept on pastures of the

- Mediterranean type. Etudes et Synthesrs de l' IEMVT. 1993, No. 41, 117-130; Actes de l' Atelier "Peut on ameliorer les performances de reproduction des camels " Paris, France, 10-12 September 1990.
- [31] Kamoun, M. (1995). Dromedary meat: production, qualitative aspects and capacity for conversion. Options Mediterraneennes Serle-B, Etudes ET Recherches. 13:105-130.
- [32] Khanna, N.N. (1988). Annual Report, Project Director, National Research Center on Camel Bikaner.
- [33] Kyriazakis, I. and J.D. Oldham. (1993). Diet selection in sheep: the ability of growing lambs to select a diet that meets their crude protein (nitrogen  $\times$  6.25) requirements. British Journal of Nutrition, 69: 617-629.
- [34] Stevens, D.R., J.C. Burns, D.S. Fisher and J.H. Eisemann. (2004). The influence of high- nitrogen forages on the voluntary feed intake of sheep. Journal of Animal Science, 82:
- [35] Konig, K.W.R. (1993). Influence of saltbush (*Atriplex spp.*) as diet component on performance of sheep and goats under semi-arid range condition. Ph. D. dissertation, Reihe Agrarwissens chaft, Institute for Animal Production in the Tropics and Subtropics, Aachen, Germany (ISBN: 3-86 III-706-1).
- [36] Alicata, M.L., G. Ahmato, A. Bona, D. Giambalvo and G. Leto. (2002). In vivo digestibility and nutritive value of *Atriplex halimus* alone and mixed with wheat straw. Journal of Agricultural Science. 139, 139-142.
- [37] El-Faramawi, A.A. (1984). Effect of drinking bring water on energy and water metabolism in sheep. M. Sc. Thesis, Ain Shams Univ.
- [38] Kandil, H.M., A.O. Sooud, M.F.A. Farid, H.M. El-Shaer, and M.A. El-Ashry. (1985). Effect of drinking saline water on feed utilization and nitrogen and mineral balance in camels. First Inter. Congress on Animal Production in Arid zones 9 ZICAPAZ, Sep., 7 – 14, 1985, ACSAD, Damascus, Syria.
- [39] Ahmed, M.H. (1984). Studies on nitrogen metabolism in ruminants: effects of drinking saline water on nitrogen metabolism and rumen kidney function in sheep. Ph. D. Thesis, Alex. Univ., Egypt.
- [40] Abou El-Nasr, H.M., M. Shawket, Safinaz, M.F. Farid and H.S. Khamis. (1988). Studies on saline drinking water for camels and sheep: 1- Water intake and excretion. Alex. J. Com. Sci. Dev. Res., 23: 131–139.
- [41] Greg, L. Charles, S. and Roxanne, J. ( 2008). Livestock and Water. NDSU Extension; 954.
- [42] Ehrienbruh , R.,M . Eknaes, and T. Pollen ,N. L. Andersen, and K. E. Bøe, (2010). Water intake in dairy goats – the effect of different types of roughages. Italian Journal of Animal volume 9 issue 4 pp 400 – 403.