Effects of type of roughage and level of concentrate supplements on feed digestion and utilization in growing female dromedary camels

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Abstract: The objectives of this study were to evaluate the effect of *ad lib* feeding three roughages (Atriplex, clover hay or rice straw) at two levels of concentrates supplementation (95% and 50% *ad lib*) on feed intake, utilization and animal performance in growing female dromedary camels. The roughages were selected to represent different grazing conditions prevailing in arid rangelands. The concentrates were corn grains and un-decorticated cottonseed meal offered separately. 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 60 days in two periods, 30 days each. Results indicated that limiting concentrates offered from 95% to 50% decreased (P <0.05) feed intake of concentrates, digestion coefficients all nutrients, ME intake, DCP intake, nitrogen intake and nitrogen balance as well as average daily gain, while increased (P <0.05) feed intake of roughage, crude fiber %DMI, rumen un-degradable protein (RUP) %TP and urinary nitrogen. Moreover, the effect of the type of roughage indicated that the atriplex-fed camels had higher (P <0.05) daily feed intake, digestion coefficient of ash and nitrogen intake. Also, the hay-fed camels had higher digestion coefficients and ME intake. The camels fed-straw were the least (P <0.05) in DN, UN and NB than the other two roughage groups. The faecal nitrogen (FN) and the ratio of NB/ND were not affected by the type of roughages. The roughage-concentrate interaction was significant (P <0.05) in cottonseed meal intake, crude protein and crude fiber digestibility and DCP intake. The results indicated that camels fed high concentrate levels at 95% *ad lib* with clover hay showed the best results concerning feed intake and digestibility, energy intake, nitrogen balance, body weight gain and feed efficiency, while those fed atriplex had the highest feed intake.

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1. Introduction

Livestock make important contributions to natural resource utilization and economical growth in developing countries where about 86% of the world's ruminants are present. Dromedary camels (*Camels dramedarius*) inhabit arid and semi-arid areas of north Africa, south- west Asia and India (Mason, 1979), in areas characterized by sparse seasonal 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 (Mcknight, 1969 and Wilson, 1984). Their food and water requirements are relatively lower than those of other species and they can extract more energy from the food they consume (Macfarlane et al., 1972; Farid et al.; 1979 and Yagil, 1981). Their low water requirements allow them to graze larger areas far from water sources in search of food (Scmidt-Nielsen, 1964).

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 compliment what the animal gets from the pasture to presumably fulfill its nutritional requirements. However, these are modified, among other things, by the animal's tendency to select his diet and its feed intake (fill) capacity.

Farid et al. (2010) reported on diet selection and feed intake capacity of stall-fed growing female dromedaries studied in a free-choice cafeteria feeding experiment. Three forages were used to represent the different grazing conditions usually prevailing in arid rangelands. Those were Egyptian clover hay, rice straw and the native salt bush, *Atriplex halimus*, corresponding to good grazing, dry season grazing and grazing arid rangelands dominated by halophytes, respectively. The concentrates used were corn grains and un-decorticated cottonseed meal usually used as energy and protein supplements.

The present experiment was intended to study the utilization of selected diets when growing camels were offered free-choice roughages and concentrates and the effect of limiting concentrate supplements on feed intake, nutrients digestion and utilization and animal performance. Results are discussed in relation to the concept and practice of supplementary feeding of herbivores grazing arid rangelands.

2. 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 weights 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 treatments, three camels each, corresponding to the different grazing conditions as represented by the roughages used (Farid et al. 2010). Those were Egyptian clover hay to represent optimum grazing conditions, rice straw to represent dry season grazing and native *Atriplex halimus* to represent arid rangelands dominated by halophytes. In addition, two concentrates were used, corn grains and un-decorticated cottonseed meal, selected as the commonly used energy and protein supplements, respectively. Proximate composition of the feed ingredients is presented in Table 1.

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. Those were, respectively, 95% and 50% of average *ad lib* roughage and concentrate intakes calculated, per unit metabolic weight ($kg^{0.73}$), from a previous experiment (Farid et al. 2010), actual intake is presented below.

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. Animals were weighed 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. Feeds and refusals were sampled and composite samples were dried and saved for pending analysis. Likewise, faeces and urine were collected each morning during the collection week. Ten percent samples were saved for pending analysis. Faeces samples were oven dried overnight at 100^{o}C whereas acidified urine samples were stored frozen at -18 ^{o}C. Composite samples were saved for each animal.

Table 1. Proximate composition of feed ingredients.

Proximate constituents	Corn grains	Cottonseed meal[1]	Egyptian Clover hay	Rice Straw	Atriplex halimus[2]
Dry matter	86.65	90.88	86.08	87.43	34.98
% DM basis					
Organic matter	98.29	75.27	86.65	78.32	74.63
Ash	1.71	24.73	13.35	21.68	25.37
Crude protein	10.76	15.84	14.26	4.55	11.70
Crude fiber	3.77	19.30	34.23	28.86	28.62
Ether extract	3.92	10.86	4.40	2.52	2.94
N-free extract	79.84	29.27	33.76	42.39	31.37
RDP[3]	7.53	10.29	10.70	1.82	8.78
RUP[3]	3.23	5.55	3.56	2.73	2.92

1. Un-decorticated, heat treated and mechanically pressed CSM, produced in a traditional oil mill,
2. Leaves and succulent branches typically consumed by grazing animals,
3. Rumen degraded protein (RDP) and rumen un-degraded protein (RUP) were calculated using factors of same or similar material from NRC (1996).

2.3. Analytical procedures:

Proximate analyses of feeds, feed refusals and faeces, as well as total urinary nitrogen, were carried out according to official procedures (A.O.A.C. 1990).

2.4. Statistical analysis:

Main effects and interactions were evaluated using the GLM repeated-measures analysis of variance procedures of the NCSS statistical package (Hintze, 2007). 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.

3. Results and Discussion

3. 1. Feed intake:

Proximate analysis of the three roughages are presented in Table 1 showed that clover hay was higher in organic matter (86.65%), crude protein (14.26%), crude fiber (34.23%), ether extract (4.4%) and RDP (10.70%), and atriplex was higher in ash (25.37%), while the straw was the least proximate constituents. The proximate analysis of feed ingredients used in this experiment was similar to those reported by Farid et al. (2010).

Data of average daily feed intake of dry matter (DMI) during the digestion trials are presented in Table 2. The results indicated that decreasing the level of concentrate from 95% to 50% of *ad lib* intake in the three roughage groups decreased (P <0.05) corn grains and cottonseed meal intakes and increased that of roughage intake and roughage DMI%.

When concentrates offered at 50%, dry matter intake from roughages increased to 35.63, 42.40 and 28.69 g DM/d/kg$^{0.73}$ in hay, atriplex and straw fed animals, respectively, an increase of 43.49, 32.25 and 43.37 percent. Reflecting upon the concept of supplementary feeding, these percentages represent reduction of pasture intake when concentrate supplementation increase from about 27 to 52 g DM/d/kg$^{0.73}$. The same trend was found by Jakhmola and Roy (1992) when growing camels were fed *ad lib* on a local Indian roughage (moth chara) with three levels of protein concentrate supplements (HPN, MPN and LPN). When concentrate supplementation increased from 0, to 18 and 28 g DM/d/Kg$^{0.75}$, roughage intake decreased significantly by 22% and 12% in the HPN group less than that of MPN and LPN, respectively. The authors indicated that this decrease may be due to limitation of the rumen fill capacity and changes in the rumen fermentation pattern. Whereas feeding low levels of concentrates stimulated cellulolytic fermentation in the rumen, whereas high levels of concentrates tend to change fermentation pattern from typical cellulolytic to amylolytic. Thus rumen retention time of roughage in the *ad lib* grains treatments as well as in the HNP group of Jakhmola and Roy (1992) might have been increased and hence, reducing the intake of roughages. The results are also in agreement with the linear trends in total DM intake observed with increasing concentrate allowance (Tan and Bryant, 1991; Faye et al., 1992 and Fahmy, 1993). Similar observation were made by Migwi et al. (2006) in Border Leicester x Merino cross wether lambs when oaten straw (7.4% CP) was supplemented with protein or protein and energy. In other experiments, however, concentrate supplementation reduced roughage intake even though total DMI increased (Jabbar and Anjum, 2008; Farid et al., 2010). The substitution effect of supplements on roughage intake or the lack of it may depend on the quantity of the supplement fed. Farid et al. (2010) reported that increasing concentrate levels caused a decline in roughage intake and increased total DMI in camels fed hay or straw, but when concentrate levels were reduced to 50% or 75% of *ad libitum* intake, roughage intake increased while total DMI decreased.

Overall, The type of roughages significantly affected roughage DMI and roughage % in DMI. Camels fed atriplex consumed significantly (P <0.05) roughage DMI and roughage % in DMI, the values being 75.60, 37.23 and 49.95 g/day/kg^{0}.^{73}, respectively. The straw-fed camels consumed the least, and the values were 63.59, 24.35 and 39.83 g/day/kg^{0}.^{73}, respectively, and those fed hay were intermediate. The roughage-concentrate interaction was not significant except, cottonseed meal intake only which was significantly affected (P <0.05).

On the other hand, roughage intake differed, and it was greatest in the atriplex group, least in the straw group and the hay group was intermediate: 37.23, 24.35 and 30.23 g DM/d/kg0.73. This was reflected upon total DM intake, i.e. the feed intake capacity, and the proportion of the roughage in total DMI. These results are consistent with the findings of Farid et al. (2010). On the other hand, when concentrates offered were only 50% of *ad lib*, and although roughage intake increased some, total DMI decreased in the three roughages. This may be due to the positive response of camels to atriplex feeding which is attributed to tow principal factors (Shawket et al. 2010). 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 (1989) that camel requires 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. These finding explain the higher (P<0.05) intake of DM, OM, TP and CF when camels fed atriplex in comparison to their mates fed either hay or straw. Second, in comparison to bovines, camel saliva contain 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 (Schmidt-Witty et al. 1994). In addition, atriplex being a lush green plant was more palatable and preferred by camels in comparison to the dry long clover hay.

Table 2. Average daily feed intake during the digestion trials, g/day/kg.$^{0.73}$

Concentrate level [C]		Roughage, *ad lib* [R] Hay	Atriplex	Straw	C-means	Repeated-measures ANOVA *(p value)* R	C	RxC
Dry matter (DMI)								
	95% *ad lib*	77.14	81.11	71.73	76.66^{b}	0.0192	0.0001	0.4289
	50% *ad lib*	62.71	70.10	55.45	62.75^{a}			
	R-means	69.92^{ab}	75.60^{b}	63.59^{a}				
	SEM ±	2.098			1.103			
Corn grains								
	95% *ad lib*	41.63	37.81	38.88	39.44^{b}	0.8503	0.0000	0.1942
	50% *ad lib*	20.03	22.12	20.35	20.84^{a}			
	R-means	30.83	29.97	29.62				
	SEM ±	1.534			0.816			
Cottonseed meal								
	95% *ad lib*	10.68	11.23	12.84	11.58^{b}	0.0640	0.0000	0.0264
	50% *ad lib*	7.03	5.58	6.41	6.34^{a}			
	R-means	8.85	8.41	9.63				
	SEM ±	0.291			0.220			
Roughage								
	95% *ad lib*	24.83	32.06	20.01	25.63^{a}	0.0005	0.0001	0.7205
	50% *ad lib*	35.63	42.40	28.69	35.58^{b}			
	R-means	30.23^{b}	37.23^{c}	24.35^{a}				
	SEM ±	1.094			0.779			
Roughage, %DMI								
	95% *ad lib*	32.22	39.44	27.92	33.19^{a}	0.0009	0.0000	0.3712
	50% *ad lib*	56.89	60.47	51.73	56.36^{b}			
	R-means	44.55^{b}	49.95^{c}	39.83^{a}				
	SEM ±	0.961			0.715			

^{a,b} 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.

3. 2. Digestion parameters of selected diets:

Digestion coefficients of diets consumed by the camels are summarized in Table 3. The results indicated that the camels fed hay was better (P <0.05) digesters than those fed atriplex and straw in dry matter, organic matter, crude fibers, ether extract and nitrogen free extract digestion, whereas digestion coefficient of crude protein was not affected. The camels fed atriplex had greater (P <0.05) ash digestion than those fed hay or straw but had the least nitrogen-free extract digestion. These results are similar to those reported by Kandil (1984) who found that, camels fed hay diet were able to digest dry matter, crude protein, crude fiber and nitrogen free extract better than their mates fed the concentrate-straw mixed diet, and found that all hay fed camels were able to digest crude fiber better than those fed the concentrate-straw mixed diet.

Limiting concentrate feeding from 95% to 50% *ad lib* decreased dry matter, organic matter, crude protein, crude fibers, ether extract and nitrogen free extract digestions, ash was not affected. The roughage-concentrate interaction of only crude protein and crude fibers digestions were significantly affected (P <0.05). Generally the results obtained in this experiment on DM, OM, CP, EE and NFE % digestibilities were in agreement with those found by Sooud, (1980), Bhattacharya et al., (1988), El-Banna (1995), Shawket and Ahmed (2001) and Mosaad et al. (2003). They reported that increasing level of energy supplementation improved nutrient digestibility, but decreased the CF digestibility. It is be lived that this apparent discrepancy could be due to the fact that the higher percentage level of grains to replace berseem hay lead to decrease in CF % in the ration and increasing concentration of readily available carbohydrates in the experimental camel rumens which were more utilizable by rumen micro flora than berseem hay crude fiber which has a lesser apparent digestibility than grains. The camels fed atriplex was increased crude protein with the limited concentrate to 50% but the other groups decreased. Atriplex does not have a well-balanced nutrient composition, with its high crude protein content and a low energy concentration. Moreover, the crude protein in atriplex contains high levels of non-protein nitrogous compounds such as glycine, betaine and proline, derived from the physiological mechanisms of salt-tolerance (Le Houerou 1992). These compounds can be utilized by rumen microorganisms to synthesize microbial proteins when atriplex is utilized in diets with highly degradable energy sources. The roughage-concentrate interaction was not significant, only crude protein and crude fibers digestions were significantly affected. The increased water flow causing a faster feed transit along the digestive tract, could have depressed the digestive utilization of atriplex on its own ,in comparison with the mixed diet.

Table 3. Apparent digestion coefficients of diets consumed by the camels, %.

Concentrate level [C]		Roughage, *ad lib* [R]			C-means	Repeated-measures ANOVA *(p value)*		
		Hay	Atriplex	Straw		R	C	Rx C
Dry matter								
	95% *ad lib*	76.40	63.21	67.29	68.97^{b}	0.0024	0.0004	0.4279
	50% *ad lib*	67.23	48.30	54.04	56.52^{a}			
	R-means	71.82^{b}	55.76^{a}	60.67^{a}				
	SEM ±	1.862			1.219			
Ash								
	95% *ad lib*	60.42	74.54	40.14	58.37	0.0002	0.1910	0.3981
	50% *ad lib*	61.46	70.45	32.88	54.93			
	R-means	60.94^{b}	72.49^{c}	36.51^{a}				
	SEM ±	2.626			1.648			
Organic matter								
	95% *ad lib*	77.90	61.30	70.77	69.99^{b}	0.0008	0.0002	0.2393
	50% *ad lib*	67.94	43.52	57.68	56.38^{a}			
	R-means	72.92^{c}	52.41^{a}	64.22^{b}				
	SEM ±	1.896			1.187			
crude protein								
	95% *ad lib*	69.22	68.48	69.82	69.17^{b}	0.0945	0.0114	0.0044
	50% *ad lib*	65.81	72.18	52.39	63.46^{a}			
	R-means	67.52	70.33	61.11				
	SEM ±	2.496			1.124			
Crude fibers								
	95% *ad lib*	51.98	41.63	29.65	41.09^{b}	0.0028	0.0354	0.0403
	50% *ad lib*	54.78	9.40	23.52	29.23^{a}			
	R-means	53.38^{b}	25.51^{a}	26.58^{a}				
	SEM ±	3.691			3.100			
Ether extract								
	95% *ad lib*	84.29	77.03	70.46	77.26^{b}	0.0093	0.0107	0.4467
	50% *ad lib*	76.54	64.67	65.61	68.94^{a}			
	R-means	80.42^{b}	70.85^{a}	68.03^{a}				
	SEM ±	1.936			1.610			
Nitrogen-free extract								
	95% *ad lib*	86.49	64.02	80.18	76.90^{b}	0.0002	0.0001	0.3852
	50% *ad lib*	74.03	48.57	69.51	64.04^{a}			
	R-means	80.26^{b}	56.29^{a}	74.85^{b}				
	SEM ±	1.777			0.931			

^{a,b} 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.

3.3. Energy and protein intake:

The data of metabolizble energy (ME) and digestible crude protein (DCP) are presented in Table 4. the results indicated that, the ME and DCP intakes g/day/kg$^{0.73}$ decreased ($P<0.05$) as concentrate offered were restricted to 50% *ad lib*. ME intake was higher ($P<0.05$) in the hay-fed camels than the atriplex and straw, while DCP intake was lower ($P<0.05$) in the straw-fed camels than the atriplex and hay-fed camels. The higher ME content of hay was due to its higher organic matter, crude protein, crude fiber and ether extract contents. On the other hand, the atriplex was higher in digested protein and so to see increased intake of protein. In this experiment may have allowed the production of more ME and fermentable products for rumen microorganisms, which may have resulted in a rise in the synthesis of microbial protein and hence the amount of protein available to the animal. An increase in the dietary protein level may have been caused a change in the process of rumen fermentation which increases fatty acid production and the ratio of propionate to fatty acids. These ruminal changes may have improved the energy balance of the rams allowing more nitrogen to be stored and thereby increasing the body weight (Kioumarsi et al., 2008; Sayed, 2009). The roughage-concentrate interaction was not significant in ME intake, while DCP intake was significantly affected.

Table 4. Average daily intake of metabolizable energy and digested protein.

Concentrate level		Roughage, *ad lib* [R]			C-	Repeated-measures ANOVA *(p value)*		
[C]		Hay	Atriplex	Straw	means	R	C	RxC
ME intake, kcal/day/kg$^{0.73}$								
	95% *ad lib*	218.3	168.4	178.2	188.3^b	0.0015	0.0000	0.9184
	50% *ad lib*	148.0	90.9	104.3	114.4^a			
	R-means	183.2^b	129.6^a	141.4^a				
	SEM $\pm$	5.837			4.982			
DCP intake, g/day/kg$^{0.73}$								
	95% *ad lib*	6.873	6.857	4.986	6.239^b	0.0002	0.0003	0.0206
	50% *ad lib*	5.519	6.182	2.364	4.688^a			
	R-means	6.196^b	6.519^b	3.675^a				
	SEM $\pm$	0.2187			0.1432			

[a,b] 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.

Table 5. Nitrogen utilization, mg N/day/kg$^{0.73}$

Concentrate level		Roughage, *ad lib* [R]			C-	Repeated-measures ANOVA *(p value)*		
[C]		Hay	Atriplex	Straw	means	R	C	Rx C
Nitrogen intake (NI)								
	95% *ad lib*	1592.1	1602.1	1140.4	1444.9^b	0.0000	0.0000	0.0296
	50% *ad lib*	1343.0	1370.3	721.7	1145.0^a			
	R-means	1467.0^b	1486.2^c	931.1^a				
	SEM $\pm$	32.11			16.29			
Faecal nitrogen (FN)								
	95% *ad lib*	492.5	505.0	342.6	446.7	0.1115	0.0936	0.2094
	50% *ad lib*	460.0	381.2	343.5	394.9			
	R-means	467.3	443.1	343.0				
	SEM $\pm$	38.56			18.41			
Digested nitrogen (DN)								
	95% *ad lib*	1099.6	1097.1	797.8	998.2^b	0.0002	0.0003	0.0206
	50% *ad lib*	883.1	998.1	378.2	750.1^a			
	R-means	991.3^b	1043.1^b	588.0^a				
	SEM $\pm$	35.00			22.92			
Urinary nitrogen (UN)								
	95% *ad lib*	374.4	263.4	195.0	277.6^a	0.0033	0.0285	0.1514
	50% *ad lib*	425.9	585.4	276.3	429.2^b			
	R-means	400.2^b	424.4^b	235.7^a				
	SEM $\pm$	24.82			37.36			
Nitrogen balance (NB)								
	95% *ad lib*	725.2	833.7	602.8	720.6^b	0.0206	0.0009	0.3967
	50% *ad lib*	457.2	403.7	101.9	320.9^a			
	R-means	591.2^b	618.7^b	352.3^a				
	SEM $\pm$	51.98			46.84			
Digested nitrogen retained (DNR=NB/DN ratio)								
	95% *ad lib*	0.6535	0.7568	0.7544	0.7215^b	0.3318	0.0013	0.1133
	50% *ad lib*	0.5183	0.4056	0.2664	0.3968^a			
	R-means	0.5859	0.5812	0.5104				
	SEM $\pm$	0.0366			0.0459			

[a,b] 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.

3.4. Nitrogen utilization:

The data of nitrogen intake and excretion in faeces and urine are shown in (Table 5).The results indicated that nitrogen intake (NI), digested nitrogen (DN), nitrogen balance (NB) and digested nitrogen retained (DNR) decreased (P <0.05), while urinary nitrogen (UN) increased (P <0.05) as concentrate offered was restricted to 50% *ad lib*, but faecel nitrogen was not affected. Between the three roughage groups, and irrespective of the level concentrate offered, the atriplex-fed camels were the highest (P <0.05) in NI, while straw-fed camels were the least (P <0.05) and those fed hay were intermediate.

These differences could mainly be due to the type of forage and its content of CP (El-Shaer and Kandil, 1990 and Shawket et al., 2002). A similar trend was observed for urinary nitrogen as mg N/day/kg$^{0.73}$ for camels fed on atriplex which was the highest (P <0.05) compared with those fed straw. This mau be may be attributed to the rapid hydrolysis of atriplex crude protein in the rumen which led to accumulation of ammonia (Weston et al., 1970) and which is inefficiently utilized in the rumen, giving rise to high blood urea nitrogen and consequently increased urinary nitrogen excretion (El-Shaer and Kandil, 1990). The camels fed-straw had the least (P <0.05) DN, UN and NB than the other two roughage groups. The faecal nitrogen (FN) and the ratio of NB/ND were not affected by the type of roughages. The roughage-concentrate interaction was significant (P <0.05) in NI and ND, while not significant in other nutrients.

Table 6. Animal performance and efficiency of ME and DCP utilization for weight gain.

Concentrate level [C]		Roughage, *ad lib* [R]			C-means	Repeated-measures ANOVA *(p value)*		
		Hay	Atriplex	Straw		R	C	RxC
Live body weight, kg								
	95% *ad lib*	389.17	355.83	383.83	376.28	0.2245	0.0000	0.0283
	50% *ad lib*	424.83	396.33	402.67	407.94			
	R-means	407.00	367.08	393.25				
	SEM ±	11.132			1.775			
Average daily gain, g/day								
	95% *ad lib*	911.46	760.42	671.88	781.25^{b}	0.0018	0.0006	0.3437
	50% *ad lib*	473.12	355.56	-10.76	272.74^{a}			
	R-means	692.29^{b}	557.99^{b}	330.56^{a}				
	SEM ±	39.483			54.655			
Efficiency of ME utilization for gain, kcal/g								
	95% *ad lib*	19.88	17.66	21.66	19.37	0.3377	0.5161	0.3225
	50% *ad lib*	27.33	34.51	-55.24	2.20			
	R-means	23.61	26.08	-16.79				
	SEM ±	21.045			17.976			
Efficiency of DCP utilization for gain, g/g								
	95% *ad lib*	0.630	0.719	0.609	0.653	0.1497	0.9497	0.2091
	50% *ad lib*	1.019	2.406	-1.322	0.701			
	R-means	0.825	1.653	-0.356				
	SEM ±	0.5946			0.5221			

^{a,b} 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.

3.5. Animal performance and the efficiency of feed utilization:

Data of animal performance and efficiency of ME and DCP utilization for weight gain of the growing female dromedaries in response to changing the type of roughage and the level of concentrate supplementation are presented in Table 6. Average daily gain and relative weight changes were higher (*P*< 0.05) in camels fed the hay and atriplex, which decreases with limiting concentrate offered to 50% of *ad lib* intake. Efficiency of ME and DCP utilization for gain were not affected. The roughage-concentrate interaction was not significant.

These results indicated that ADG was affected significantly (p≤0.05) by the type of roughages. In this respect, Kamoun et al. (1989) found that the ADG ranged from 326 to 525 g/d in one-year old camels fed on *ad libitum* hay plus concentrate (80% wheat bran). While Etman (1997) found that the ADG was 412 g for camels fed berseem or hay plus concentrate, and it was 386 g/d for camels fed wheat straw plus concentrate. However, Faye et al. (1992) indicated that ADG was 550 g/d for concentrate-supplemented camels, (570 g/d for concentrate plus mineral supplement). Kamoun (1993 and 1995) demonstrated that the daily gain of the growing camels was 605 g/d from five to ten months of age, and just 280 g with the diet having 22% protein. Khanna (1988) reported that values of daily gain of Kutchi and Bikaneri camels were 800 and 749 g, respectively, up to three months of age.

Conclusion

In conclusion, the present results indicate that growing female camels grazing during the dry season (e.g. straw feeding) need supplementary feeding at relatively high levels approximating concentrate ad lib intake. Under optimum grazing conditions (e.g. clover hay feeding) supplementation at the 50% ad lib level promoted reasonable weight gain and efficiency of ME and DCP utilization. However, if stocking rate is high or the animal movement is restricted higher levels would be needed. Camels grazing halophytes (e.g. Atriplex feeding) responded to supplementation in a way similar to their clover hay fed mates but was less in magnitude and efficiency. The present results are of importance when attempting to devise a supplementary feeding regime for growing camels on the range.

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