Diet Selection, Feed Intake Capacity and Performance of Growing Female Camels: Effects of Type of Roughage and Level of Concentrates Offered

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Abstract: The feeding trials were intended 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. Eighteen growing she-camels were randomly allotted to three groups. Each group was assigned one of the three roughages offered ad lib for the duration of the whole experiment. Results indicated that type of roughage and concentrate levels, and their interaction, affected ($P<0.05$) FIC and diet selection, and consequently live weight gain. Average total and roughage DMI were 78.9 and 16.1, 83.9 and 22.5, 96.4 and 33.4 g DM/day/$Kg^{0.75}$ for straw, hay and atriplex groups, respectively. Irrespective of the roughage fed, growing camels consumed three-times as much corn grains as that from the cottonseed meal. Limiting concentrates offered to 75% or 50% of ad lib intake, decreased FIC, while the proportion of roughages in DMI increased significantly, total OMI and total protein decreased and crude fibres intake increased, more so in the straw fed camels. The Atriplex fed camels recorded the higher ADG, followed by the hay fed ones and the straw fed mates grew the least, 516, 429 and 240 g/d, respectively. Restricting the level of concentrates offered decreased significantly ($P<0.05$) the ADG (691, 305 and 189 g/d in camels fed 100, 75 and 50% of ad lib concentrate intake. These results tend to indicate 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. [Journal of American Science. 2010;6(11):317-326]. (ISSN: 1545-1003).

Key words: camels, diet selection, feed intake capacity, weight gain

1. Introduction

Camels are famed for their peculiar adaptation to the harsh conditions prevailing in arid zones. They possess distinct behavioral, physiological and nutritional adaptive mechanisms that enable them withstand extreme direct and indirect environmental stresses (Schmidt-Nielsen 1964, Farid et al. 1979, 1997, Gauthier-Pilters 1979, Gauthier-Pilters and Dagg 1981). These animals, like other herbivores grazing arid rangelands, are seasonally challenged with feed and water deficiencies, both in quantity and quality.

Earlier studies indicated that yearling and older camels can be maintained and even fattened on clover hay, grain straws or native halophytes (e.g. *Atriplex sp.* and *Acacia saligna*) supplemented with different levels of grains as energy sources (Shawket 1999, Shawket and Ahmed 2001, Shawket et al. 2005). Similar experiments on pregnant and lactating camels were conducted (Shawket et al. 2009). Results were encouraging in terms of the overall performance realized. It seems that performance was largely dependent both on the type of roughage constituting the basal diet and the concentrate supplement. Differences between species, camels vs. sheep or goats, were also recorded (Farid et al. 1979, Farid et al. 1997). Camels were found to out-perform other species in utilizing nutritionally lower quality or imbalanced diets. However, differences between species were minimal when receiving adequate and better balanced diets.

The present investigation was intended to study, in growing female dromedaries, feed intake capacity, diet selection and live weight changes in relation to the type of roughage offered and the effect thereon of concentrate supplementation. The roughages used were

intended to represent different grazing conditions typically prevailing in arid rangelands. Free choice cafeteria feeding was employed to facilitate the study of diet selection and to assess the animals' feed intake capacity. Results are discussed in relation to the practice of supplementary feeding of grazing herbivores in arid rangelands, and in the light of factors affecting voluntary food intake.

2. Materials and Methods

2.1. Animals and management

Eighteen healthy growing she-camels were used in the present experiment to study diet selection and feed intake capacity, as well as their live weight changes under simulated grazing conditions and the effect of supplementary feeding. They were 24-30 months old and their live body weight averaged 393.1±27.02 kg (range: 349.5-445.0 kg). Animals were housed individually in shaded floor pens for the duration of the experiment. They were weighed every two weeks after overnight fast and on two consecutive days. Their average daily gain was calculated for each period.

2.2. Feeds and feeding

The different grazing conditions prevailing in arid rangelands were represented by the three roughages used. Those were 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. The concentrates used were corn grains and cottonseed meal selected as the commonly used energy and protein supplements, respectively.

Roughage feeding was ad lib throughout and offered twice daily at 8:00 and 16:00 hours. Refusals, if any, were weighed the following morning and daily intake was recorded on dry matter basis. Concentrates, when fed ad lib, were restricted to only 10 hours daily, from 8:00 to 18:00 hours daily, in an attempt to control anticipated excessive soluble carbohydrates intake and possible adverse effects on rumen function and feed utilization (Farid et al. 2005a, 2005b). Water was made available free choice once daily at the morning feeding time. The proximate composition of feed ingredients is presented in Table 1.

Table 1. Proximate composition of feed ingredients, % DM basis.

Proximate constituents	Egyptian Clover hay	Rice Straw	Atriplex halimus[2]	Corn grains	Cottonseed meal[1]
Dry matter	86.08	87.43	34.98	86.65	90.88
Ash	13.35	21.68	25.01	1.71	24.73
Organic matter	86.85	78.32	74.99	98.29	75.27
Total (crude) protein	14.26	4.55	11.70	10.76	15.84
Crude fibres	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

1. Un-decorticated, heat treated and mechanically pressed CSM, produced in a traditional mill,
2. Leaves and succulent branches typically consumed by grazing animals,

2.3. Cafeteria feeding trials

The feeding trials were intended to investigate diet selection and feed intake capacity when roughages and concentrates were fed ad lib, and the effect on roughage intake and animal performance when concentrates were restricted. In order to achieve this goal, a free-choice cafeteria feeding system was used. Feeders were divided to allow for the separate offering of feed ingredients and hence the recording of daily intake from each.

The animals were randomly allotted to three groups, six animals each. Each group was assigned one of the three roughages offered ad lib for the duration of the whole experiment.

The feeding trials lasted 100 days in four consecutive periods. The first period (14 days) was intended to gradually introduce the animals to full free-choice roughage and concentrate intake. This was followed by a second period (33 days) where individual intakes were recorded daily when all roughage and concentrate ingredients were fed ad lib. During the third period (22 days) roughages were fed ad

lib but concentrates offered were reduced to 75% of average ad lib intake recorded during the second period. Concentrates offered were further limited to only 50% of ad lib during the fourth period (31 days). Daily intake from each ingredient was recorded separately for each animal throughout the experiment.

2.4. Analytical procedures and calculations

Determination of the proximate composition of feeds (Table 1) was carried out according to official procedures (A.O.A.C. 1990). Nutrients intake were calculated form feed ingredients intake recorded daily and their determined organic matter, total protein and crude fibres contents.

2.5. 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. Duncan's multiple-range test was applied to the means of the main effects and to the two-way interactions (Duncan, 1955).

3. Results

3.1. Dry matter intake

Average daily feed intake data for the 100-day experimental period are illustrated in Figure 1. During the two-week adaptation period, as the amount of concentrates offered increased roughage intake decreased but total DM intake increased. Thereafter, and during the following 33 days when all roughage and concentrate ingredients were offered free-choice, grain intake continued to increase whereas cottonseed meal and roughages decreased, and total DMI decreased as well. This lasted for about two weeks only. Grains intake then tended to decrease and cottonseed meal and the roughage increased but only slightly. Total DMI exhibited a gradually decreasing trend especially in the straw-fed group. Similar patterns of probable rhythmic responses were observed earlier in camels, sheep and goats (Farid et al. 1997).

Limiting the concentrates offered to 75% and 50% of ad lib intake in the hay and straw fed groups increased roughage intake but total DMI decreased. However, in the atriplex-fed group the increase in roughage intake was substantial and total DMI was not practically different from that when concentrates offered were not limited.

3.2. Diet selection and feed intake capacity

When both roughages and concentrates were offered free-choice, total DMI was regarded as the animal's most favorable feed intake capacity (FIC). The results (Table 2) indicated that the type of roughage and concentrate levels, and their interaction, significantly affected FIC and diet selection. Camels offered the rice straw consumed the least total and roughage DM (78.9 and 16.1 g DM /day/$kg^{0.73}$, respectively), and the roughage proportion in the consumed diet was low (20.6%). When fed the better quality clover hay, on the other hand, camels consumed more total and roughage DM (83.9 and 22.5 g DM /day/$kg^{0.73}$, respectively), and the roughage proportion in the consumed diet increased to (26.9%). Noteworthy, feeding the native saltbush *Atriplex halimus* promoted better DMI, both total and from the roughage (96.4 and 33.4 g DM /day/$kg^{0.73}$, respectively), and the roughage proportion in the consumed diet was practically optimum at 34.7%.

Irrespective of the roughage fed, camels consumed, on average, three-times as much corn grains as that from the cottonseed meal, 47.2 vs. 15.1 g DM /day/$kg^{0.73}$, respectively. Between roughages, Atriplex promoted more grain and less meal intake than hay, and straw was intermediate. This might indicate that grains as a source of available carbohydrates were preferred when total and soluble nitrogen contents were higher in the roughage.

3.3. Effects of limiting concentrate intake on total and roughage intake

On average, when concentrates offered were limited to 75% and 50% of respective ad lib intake in the three roughage groups (Table 2), roughage DMI as well as the roughage proportion in total DMI increased significantly, whereas total DMI decreased. The atriplex-fed camels appeared at advantage when concentrate feeding was limited. When fed the 50% concentrate supplements their total DMI amounted to 100.0 g/day/$kg^{0.73}$, and a high 71% of which came from the roughage. Their straw-fed mates, on the other hand, were only able to consume half as much total DMI (56.2 g/day/$kg^{0.73}$), only half of it came from straw (48.8%). Although clover hay is considered good dry roughage, results from the hay-fed camels were intermediate but more like that from the straw-fed mates. Their total DMI was 64.2 g/day/$kg^{0.73}$ and hay comprised a satisfactory 55.4% of it.

3.4. Nutrients intake

Organic matter (OM), total protein (TP) and crude fibres (CF) intakes were calculated

from the proximate composition of ingredients and the ingredients' DM intake (Table 3). On average, restricting concentrate feeding to 75% and 50% of ad lib intake decreased organic matter and total protein intake and increased crude fibres intake per unit metabolic size, $kg^{0.73}$. Between the three roughage groups, and irrespective of the level of concentrate offered, the atriplex-fed camels consumed significantly more of the three nutrients, OM, TP and CF, than camels in the other two roughage groups. The straw-fed camels consumed the least and those fed hay were intermediate.

The decrease in total OM intake as concentrates offered were restricted to 50% ad lib amounted to only 4.4% in the atriplex-fed camels, whereas it was 24.6% and 32.1% in the hay- and straw-fed camels, respectively.

Total protein (TP) intake increased slightly (3.5%) in camels fed the atriplex, but decreased 20.1% and 43.2% in their hay- and straw-fed mates when concentrates offered were limited to 50% of ad lib. On the other hand, crude fibres intake increased in all three roughage groups, more so (61.3%) in the atriplex-fed camels which experienced the least decrease in total OM intake. The increased CF intake amounted to 13.6% and 7.7% in the hay- and straw-fed camels, respectively.

Table 2. Diet selection and feed intake capacity of growing female dromedaries

Roughage feeding groups [R]	Concentrate feeding level [C] % *ad lib* 100	75	50	R-means	SEM ±	F-test[1] (*P* =)
Total DM intake, g DM/d/$kg^{0.73}$						
Hay	83.89^{c}	63.56^{b}	64.18^{b}	**70.54^{A}**	1.227	R 0.000
Atriplex	96.39^{d}	89.28^{c}	99.98^{d}	**95.22^{B}**		C 0.000
Straw	78.92^{c}	66.41^{b}	56.16^{a}	**67.17^{A}**		RC 0.000
C-means	**86.40^{B}**	**73.09^{A}**	**73.44^{A}**			
Roughage intake, g DM/d/$kg^{0.73}$						
Hay	22.53^{b}	23.27^{b}	35.54^{d}	**27.11^{B}**	0.652	R 0.000
Atriplex	33.37^{d}	49.75^{e}	71.18^{f}	**51.47^{C}**		C 0.000
Straw	16.11^{a}	26.52^{c}	27.38^{c}	**23.34^{A}**		RC 0.000
C-means	**24.04^{A}**	**33.18^{B}**	**44.70^{C}**			
Roughage, % in DMI						
Hay	26.87^{a}	36.76^{b}	55.37^{e}	**39.66^{B}**	0.694	R 0.000
Atriplex	34.72^{b}	55.76^{e}	71.24^{f}	**53.91^{C}**		C 0.000
Straw	20.57^{a}	40.06^{c}	48.77^{d}	**36.47^{A}**		RC 0.000
C-means	**27.39^{A}**	**44.19^{B}**	**58.46^{C}**			
Corn grains intake, g DM/d/$kg^{0.73}$						
Hay	43.09^{bc}	28.85^{b}	20.21^{a}	**30.71^{A}**	1.025	R 0.088
Atriplex	50.82^{c}	31.94^{b}	23.29^{a}	**35.35^{B}**		C 0.000
Straw	47.84^{c}	31.52^{b}	21.89^{a}	**33.75^{B}**		RC 0.157
C-means	**47.25^{C}**	**30.77^{B}**	**21.80^{A}**			
Cottonseed meal intake, g DM/d/$kg^{0.73}$						
Hay	18.27^{e}	11.45^{c}	8.43^{b}	**12.72^{C}**	0.332	R 0.000
Atriplex	12.10^{c}	7.59^{b}	5.51^{a}	**8.40^{A}**		C 0.000
Straw	14.97^{d}	8.38^{b}	6.89^{ab}	**10.08^{B}**		RC 0.000
C-means	**15.11^{C}**	**9.14^{B}**	**6.94^{A}**			

1. Repeated-measures ANOVA results, only *p* values for main effects and the two-way interaction are shown, adjusted total df = 53,

A-C Means within a main effect, C-means or R-means, not sharing a superscript were significantly (P<0.05) different according to Duncan's multiple range test.

a-f Duncan's multiple range test was performed on the nine means from the RC interaction, and for each parameter, means within a parameter not sharing a superscript were significantly (P<0.05) different.

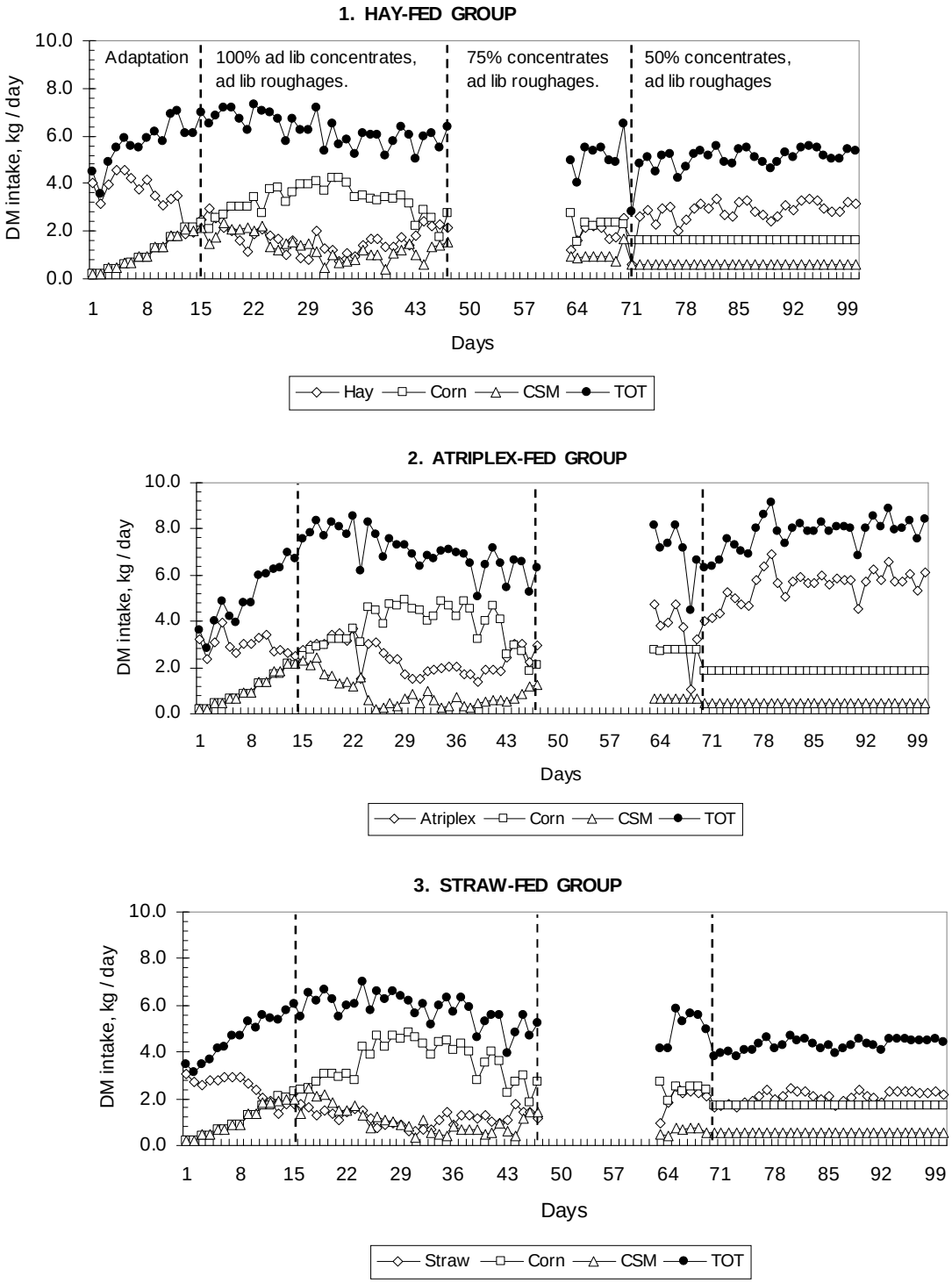

Figure 1. Average daily dry matter intake (kg/day) from individual feed ingredients during periods of free-choice and restricted concentrates supplementation and the effect of the type of roughage.

Table 3. Average daily weight changes and nutrients intake

Roughage feeding groups [R]	Concentrate feeding level [C] % *ad lib* 100	75	50	R-means	SEM ±	F-test[1] (*P* =)
Average daily gain, g/d						
Hay group	744.7^{b}	297.7^{ab}	244.5^{ab}	**428.9^{A}**	148.67	R 0.248
Atriplex group	735.8^{b}	523.7^{ab}	289.0^{ab}	**516.2^{A}**		C 0.001
Straw group	594.7^{ab}	95.2^{a}	32.2^{a}	**240.3^{A}**		RC 0.889
C-means	**691.4^{B}**	**305.5^{A}**	**188.6^{A}**			
OM intake[2], g DM/d/kg$^{0.73}$						
Hay	75.67^{cd}	57.18^{b}	57.07^{b}	**63.31^{A}**	1.143	R 0.000
Atriplex	84.16^{d}	74.42^{cd}	80.42^{d}	**79.66^{B}**		C 0.000
Straw	70.91^{c}	58.05^{b}	48.15^{a}	**59.04^{A}**		RC 0.000
C-means	**76.91^{B}**	**63.22^{A}**	**61.88^{A}**			
TP intake[2], g DM/d/kg$^{0.73}$						
Hay	10.74^{de}	8.24^{c}	8.58^{c}	**9.19^{B}**	0.141	R 0.000
Atriplex	11.30^{de}	10.46^{d}	11.71^{e}	**11.16^{C}**		C 0.000
Straw	8.25^{c}	5.93^{b}	4.69^{a}	**6.29^{A}**		RC 0.000
C-means	**10.10^{B}**	**8.21^{A}**	**8.33^{A}**			
CF intake[2], g DM/d/kg$^{0.73}$						
Hay	12.86^{c}	11.26^{b}	14.55^{d}	**12.89^{B}**	0.205	R 0.000
Atriplex	13.83^{cd}	16.91^{e}	22.31^{f}	**17.68^{C}**		C 0.000
Straw	9.34^{a}	10.46^{ab}	10.06^{a}	**9.95^{A}**		RC 0.000
C-means	**12.01^{A}**	**12.88^{B}**	**15.64^{C}**			

1. Repeated-measures ANOVA results, only *p* values for main effects and the two-way interaction are shown, adjusted total df = 53,
2. Calculated from the proximate composition of ingredients (Table1) and ingredients' DM intake (Table 2),

A-C Means within a main effect, C-means or R-means, not sharing a superscript were significantly (P<0.05) different according to Duncan's multiple range test.

a-f Duncan's multiple range test was performed on the nine means from the RC interaction, and for each parameter, means within a parameter not sharing a superscript were significantly (P<0.05) different.

3.5. Animal performance

Data on average daily weight gain (ADG) of the growing female dromedaries in response to changing the type of roughage and the level of concentrate supplementation are presented in Table 3. Overall, between and within variation were great as indicated by the substantial pooled SEM value. However, the lack of statistical significance of differences between roughage means should not mask the biological significance of the observed results.

On average, the atriplex-fed animals gained the most, followed by the hay-fed ones and the straw-fed mates grew the least. Observed ADG values were 516, 429 and 240 g/d, respectively. The effect of the level of concentrate feeding on ADG was also evident. It amounted, on average, to 691, 305 and 189 g/d in camels fed 100, 75 and 50 percent of ad lib concentrate intake. The roughage-concentrate interaction was not significant.

As indicated above, decreasing the level of concentrate supplementation decreased organic matter and total protein intake and increased that of crude fibres. Atriplex feeding promoted better intake of all three nutrients as compared to hay-feeding, whereas straw-feeding resulted in the least intake. These are in accord with observed effects on performance.

4. Discussion

Ruminant herbivores are characterized by their multi-compartmented stomach. This anatomical structure and the microorganisms inhabiting the rumen-reticulum allow for longer retention of ingested food and the anaerobic microbial digestion of cellulosic material, and hence the production of volatile fatty acids and the synthesis of microbial protein, all are for the benefit of the host animal. The camel is a

pseudo-ruminant. It also has a multi-compartmented stomach but the two compartments, omasum and abomasum, are fused together into one 'tubiform' compartment. Nevertheless, it is functionally and metabolically a ruminant herbivore.

Voluntary food intake and the selection between foods when offered free choice for ad lib feeding are important issues of continued interest. High levels of voluntary intake are required for efficient production, in general, because the more the animal eats the more it produces. Selection between foods is how the animal attempts to acquire a 'balanced' diet to supply essential nutrients commensurate with its basic needs for maintenance and potential production, and including continued fat deposition in the adult. Grazing herbivores have been known to select diets that are richer in nutrients and lower in toxins than the average composition of available vegetation (Fontenot and Blaser, 1965, Arnold, 1970).

In natural environments the availability and composition of foods vary both spatially and temporally. In arid rangelands there are distinct grazing and dry seasons. In addition, animals also graze halophytes dominant in certain areas and depressions. Under these conditions grazing ruminants, camels included, are challenged with seasonal shortage of food and water, both in quantity and quality. Supplementary feeding is then not an uncommon practice. Properly practiced, and in addition to economic considerations and the fact that achieving the full production potential may not be the realistic objective under certain conditions, the following, among other things, need to receive appropriate consideration: (a) supplementation should be an addition to what the animal is able to acquire from the available pasture and not to replace it, (b) to compliment and balance nutrients needed by the animal but deficient in the pasture, (c) does not restrict the mobility of the animal on the range, (d) does not increase the need for free drinking water usually in short supply under these conditions even when the animals are adapted to intermittent water intake and (e) expected total intake not to exceed the animal's expected feed intake capacity, otherwise the objectives and benefits of supplementation would not be realized.

The present experiment addressed some of these topics as related to the supplementary feeding of growing she camels in arid rangelands. The roughages used were chosen to represent different arid grazing conditions. They were clover hay to represent optimum quality grazing, straw to represent dry season grazing and atriplex to represent grazing in areas dominated by halophytes. The results are foreseen to be of value when attempting to develop appropriate supplementary feeding system for camels inhabiting such environments.

Although not experimentally demonstrated in the present study, it is acknowledged that the three roughages used and the liberal concentrate ingredients offered imposed different sets of factors known to affect the regulation of voluntary food intake of the animals. In all three roughage groups, liberal intake of corn grains especially when offered ad lib might have increased rumen acidity and osmolality and intensified the effect of propionate in the liver and impair fiber digestion (Hoover 1986, Nsahlai and Umunna 1996 and Faverdin 1999). Long term adjustment to liberal corn feeding was observed as of about day 30 and beyond (Fig. 1) where corn grains intake started to decrease, roughage and cottonseed meal intake increased and total DMI decreased.

In the atriplex fed animals, the high content of sodium chloride and soluble proteins might have resulted in increased rumen osmolality and ammonia concentration, both known to negatively affect VFI (Kyriazakis and Oldham 1993 and Stevens et al. 2004). 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 by Konig (1993) and Alicata et al. (2002). In the straw fed group, its poor digestibility, longer retention time in the GIT and low nutritive value (Cianci et al. 2004) did limit the VFI and adversely affected animal performance.

Ad lib feeding of concentrates along with ad lib roughages resulted in similar intakes of total concentrates, the sum of corn grains and cottonseed meal, amounting to 61-63 g DM/d/kg$^{0.73}$ irrespective of the roughage offered and the different ratio of grains to meal. Roughage intake differed, however. It was greatest in the atriplex group, least in the straw group and the hay group was intermediate: 33.4, 16.1 and 22.5 g DM/d/kg$^{0.73}$. This was reflected upon total DM intake, i.e. the feed intake capacity, and the proportion of the roughage in total DMI.

Maximum feed intake capacity at free choice ad lib feeding amounted to 84, 96 and 79 g DM/d/kg$^{0.73}$ for camels fed hay, atriplex and straw, respectively. The present VFI capacity values of hay and straw were close to those indicated by Farid et al. (1997), being 87 and 79 g DM/Kg$^{0.75}$ for adult camels fed free choice ad lib concentrate mixture and barley grains with either clover hay or rice straw, respectively. When concentrates offered were only 50% of ad lib (28 g DM/d/kg$^{0.73}$), and although roughage intake increased some, feed

intake capacity (total DMI) decreased to 64 and 56 g DM/d/kg$^{0.73}$, in camels fed hay and straw, respectively. Noteworthy, it was not affected in the atriplex fed camels where it amounted to 100 g DM/d/kg$^{0.73}$. 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. So, 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.

When concentrates offered were limited, dry matter intake from roughages increased to 35.5, 71.2 and 27.4 g DM/d/kg$^{0.73}$ in hay, atriplex and straw fed animals, respectively, an increase of 58, 113 and 70 percent. Reflecting upon the concept of supplementary feeding, these percentages represent reduction of pasture intake when concentrate supplementation increase from about 28 to 63 g DM/d/kg$^{0.73}$. The same trend, it 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 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 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. In comparison, Shawket and Ahmed (2001) reported that intake of adult camels from Atriplex nummularia, which is nutritionally superior to A. halimus, increased from 53.7 g DM/d/kg$^{0.75}$ when fed alone to 69.6 g DM/d/kg$^{0.75}$ when a supplement of corn grains was offered to supply only 40% of the ME required for maintenance (Farid 1995). The corn grains supplement amounted to 13.5 g DM/d/kg$^{0.75}$, equal to 21% of ad lib concentrate supplement realized in the present experiment. The present result of feed preference by camels is supported by the finding of Rutagwanda et al. (1990) that camels are superior to other species in selecting plants and feeds of better quality. It was concluded that animals have developed mechanisms, behavioral and else, that allow them to recognize foods on the basis of their nutritional as well as other properties (Kyriazakis et al., 1999).

Decreasing the level of concentrate supplementation to 75% and 50% decreased the ADG by 56% and 73%, respectively less than that of ad lib concentrate supplementation. The same trend was reported by Jakhmola and Roy (1992), for growing camels. It is noticeable that atriplex-feeding with ad lib concentrate supplementation or when limited to 75% and 50% of ad lib, recorded the highest DMI capacity in comparison to hay or straw-feeding. These reflected the camel preference to salty roughages as discussed above. Irrespective of the level of concentrate offered, atriplex feeding promoted better intake of all three nutrients, OM, TP and CF, as compared to hay or straw-feeding resulting in the highest observed ADG. Similar results were reported earlier by Shawket et al. (2010) who indicated that growing camels fed atriplex supplemented with crushed barley grains (100% of their growth energy requirements, Wardeh and Farid 1990) recorded higher ($P<0.05$) ADG than their mates fed hay, 560 g/d vs. 421 g/d, respectively.

5. Implications

Supplementation during optimum grazing season is practiced only if the pasture is over- stocked, animal movement is restricted or nutrient requirements are high during demanding physiological or productive states. On the other hand, supplementary feeding during the dry season or when grazing halophytes is practiced to rectify deficiencies and imbalances of nutrients in the available pasture, frequently at or below the maintenance level of feeding to minimize losses in life and condition.

Developing supplementary feeding schemes for camels, like other ruminant herbivores, require knowledge of their requirements especially at maintenance (Farid et al. 1990, Farid, 1995). These were translated into provisional requirements for different physiological and productive states (Wardeh and Farid 1990). Secondly, it was essential to evaluate in growing she camels, the present

experiment, diet selection and the maximum feed intake capacity under ad lib cafeteria feeding conditions, and the effect thereon of restricting the concentrate supplements, while using three roughages to simulate the different arid grazing conditions indicated above. The study under these controlled conditions was not expected to deviate much from natural conditions. Kyriazakis et al. (1999) stated that even under partly artificial conditions the diet selected will follow from the general adaptive nature of the animal's feeding behavior.

The present results provide preliminary guidelines to the supplementary feeding of camels under different grazing conditions. Of paramount importance, the camel's preference for concentrates and the reduction of their intake from roughages, i.e. the pasture, when supplements are abundant. The results are supported by the findings of Yacout and El-Badawy (2001) and taking into consideration the fact that responses of ruminants to energy and protein intake are not independent (Blaxter 1975). However, it seems that camels are more sensitive to energy than protein deficiency and supplementation and they can utilize poor quality roughages if forced to use exclusively on it (Holler et al. 1986, Lechner and Englehardt 1989).

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6. References

1. 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. I39, 139-142.
2. AOAC – Association of Official Agricultural Chemists. 1990. Official Methods of Analysis, 15th edition. AOAC, Washington DC.
3. Arnold, G.W. (1970). Regulation of food intake in grazing ruminants. In: Phillipson, A.T. (Ed). Physiology of Digestion and Metabolism in Ruminant. p. 264-276. Oriel Press, Newcastle.
4. Blaxter, K.L. (1975). Energy-protien relationships in ruminants. Proceedings, 9th International Congress of Nutrition. Mexico, 1972, Vol. 3, p. 122-127.
5. Chamberlain, A. (1989). Milk production in the tropics. Intermediate Tropical Agricultural Series 13, Camels, 202-210.
6. 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.
7. Duncan, D. (1955). Multiple range and multiple-F-tests. Biometrics, 11: 1-42.
8. Farid, M.F.A. (1995). Nutrient requirements of dromedary camels: Protein and energy requirements for maintenance. Journal of Arid Environments,.30: 207-218.
9. Farid, M.F.A., H.S. Khamis, H.M. Abou El-Nasr, M.H. Ahmed and S.M. Shawket. (1997). Diet selection and food intake capacity of stall-fed sheep, goats and camels in relation to some physical properties of foods and their potential digestion in the rumen. Options Mediterraneennes, Seri A, 34: 109-114.
10. Farid, M.F.A., H.S. Khamis, E.Y.A. Eid and A. Helal. (2005a). Feeding management and the performance of sheep in southern Sinai: 1. Diet selection and voluntary food intake of ewes. Journal of Agricultural Science, Mansoura University. 30: 7437-7456.
11. Farid, M.F.A., H.S. Khamis, E.Y.A. Eid and A. Helal. (2005b). Feeding management and the performance of sheep in southern Sinai: 2. Reproduction and production performance of the ewe. Journal of Agriculture Science, Mansoura University, 30: 7457-7475.
12. Farid, M.F.A., S.M. Shawket and M.H. Abdel- Rahman. (1979). Observations on the nutrition of camels and sheep under stress. Proc. IFS. Workshop on Camels, Khartoum, Sudan, 15-20 Dec., (1979), IFS Provisional Report, 6, 125.
13. Farid, M.F.A., S.H. Shawket and H.M. Abou El-Nasr. (1990). The maintenance requirements of camels: a preliminary evaluation. Alexandria Journal of Agriculture Research, 35: 59-66.
14. Faverdin, P. (1999). The effect of nutrients on feed intake in ruminants. Proceedings of the Nutrition Society. 58, 523-531.
15. Fontenot, J.P. and R.E. Blaser. (1965). Symposium on factors influencing the voluntary intake of herbage by ruminants: selection and intake by grazing animals. Journal of Animal Science, 24: 1202-1208.
16. Gauther-Pilters, H. (1979). Some ecological aspects of the camel in the Eastern Sahara. In Cockrill (ed). The Camelid: An All Purpose Animal Proc. Workshop on Camels. Khartoum, Sudan, 15-20 Dec. 1979.
17. Gauthier-Pilters, Hilde and A.I. Dagg. 1981. The camel: its evolution, ecology, behaviour and relationship to man. University of Chicago Press. 208pp.

18. Gihad, E.A., T.T. El-Gallad, A.O. Sooud, H.M. Abou El-Nasr and M.F.A. Farid. (1988). Feed and water intake, digestibility and nitrogen utilization by camels compared to sheep and goats fed low protein desert by-products. Seminair sur la digestion, la nutrition et l'alimentation du dromadaire, Ourgala, Algerie. February 28, March 1, 1988.
19. Holler, R., M. Lechner, H. Weyreter and W. and Von Engelhardt. (1986). Fore stomach fluid volume and retention time of fluid and particles in the gastrointestinal tract of the camel. Journal of Veterinary Medicine, A., 33: 396.
20. Hoover, W.H. (1986). Chemical factors involved in ruminal fiber digestion. Journal of Dairy Science, 69: 2755-2766.
21. Hintze, (2007). NCSS. Kaysville, Utah, U.S.A.
22. Jakhmola, R.C. and A.K. Roy. (1992). Effect of supplementation of concentrate on body-weight gain and serum constituents in camel. Indian Journal of Animal Sciences, 62: 782-784.
23. 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 Agrarwissenschaft, Institute for Animal Production in the Tropics and Subtropics, Aachen, Germany (ISBN: 3-86 III-706-1).
24. 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 × 6.25) requirements. British Journal of Nutrition, 69: 617-629.
25. Kyriazakis, I., B.J. Tolkamp and G.C. Emmans. (1999). Diet selection and animal state: an integrative framework. Proceedings of the Nutrition Society, 58: 765-772.
26. Lechner, M. and W. Von Engelhardt. (1989). Particle size and passage from the fore stomach in camels compared to cattle and sheep fed similar diet. Journal of Animal Physiology and Animal Nutrition, 61: 120.
27. Nsahlai, I.V. and N.N. Umunna. (1996). Sesbania and lablab supplementation of oat hay basal diet fed to sheep with or without maize grain. Animal Feed Science and Technology, 61: 275-289.
28. Rutagwanda, T.M. Lechner, H.J. Schullka and W. Von Engelhardt. (1990). Dietary preference and degradability of forage on a semi-arid thornbush savannah hay indigenous ruminants, camels and donkeys. Animal Feed Science and Technology, 31: 179.
29. Schmidt-Nielson, K. (1964). Desert Animals. Oxford University Press, London.
30. Shawket, S.M. (1999). Fattening of camel calves on saltbush (Atriplex halimus) with different energy sources. Journals of Agricultural Science, Mansoura University, 24: 1751-1764.
31. Shawket, S.M. and M.H. Ahmed. (2001). The influence of the level of energy supplementation on the utilization of saltbush (Atriplex nummularia) by camels. Egyptian Journal of Nutrition and Feeds, 4: 557-565.
32. Shawket, S.M. and M.H. Ahmed. (2009). Effect of prolonged feeding Atriplex (saltbush) to camels on digestibility, nutritive value and nitrogen utilization. Egyptian Journal of Nutrition and Feeds, 12: 205-214.
33. 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.
34. Shawket, S.M., H.S. Ziwal, M.H. Ahmed, A.M. Nour and A.M. Abd El-Wahed. (2005). Camel,s performance response to dietary energy level under semi-arid conditions. Egyptian Journal of Nutrition and Feeds, 8: 211-223.
35. 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: 1536-1542.
36. Wardeh, M.F. and M.F.A. Farid. (1990). Nutrient requirements (Energy and Protein) of the dromedary camels. Symposium, Animal Science Divisions in the Arab Universities and Workshop on Development of Camel Production, March 4-7, 1990. Al-Ain University, United Arab Emirates.
37. Yacout, M.H. and A.Y. El- Badawi. (2001). Effect of dietary protein level on fattening performance of camel calves. Egyptian Journal of Nutrition And Feeds, 4: 545-556.

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