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SUMMARY - Dry matter intake (DMI) or energy intake, digestive capacity and feed utilization have been studied in the dromedary camel using coarse roughages under stall-fed conditions. DMI of meadow hay (MH), wheat straw (WS) and oat hay (OH) was, respectively, 0.92, 0.65 and 0.66 kg DM per 100 kg lw. With these types of feeds, the camel's natural ability for selective browsing is reduced and there is reduced feed intake even with limited dehydration. Intake improved with supplementary feeding. Consumption of OH by adult camels increased by 16%. Total DMI increased by over 60% when WS was offered with a high-CP supplement. However, total DMI of this species remained, in any case, limited (1.6-1.7 kg DM per 100 kg lw) even with high concentrate level (over 50% of total diet on DM basis). With young growing animals DMI of WS increased as supplementary protein level increased from 15 to 22% after which it slightly decreased or levelled off with further increases in CP level. DM digestibilities of WS and MH were, respectively, 44.8 and 55.9%. OM digestibility of WS improved by over 16% with high-CP supplement. However the digestibility of NDF, ADF and cellulose was lower than those of the non-supplemented group. The DE content of WS and MH was respectively 8 and 10 MJ per kg DM. With a basal diet of WS plus a concentrate supplement and providing approximately 10.5 MJ ME per kg, adequate milk yields (6 l) and positive weight change balance were achieved, suggesting that the energy intake of lactating camels would be slightly less than that of lactating cows with similar production performance. Similarly, young growing camels achieved an ADG of 285 g when offered a diet providing approximately 8.5 MJ ME per kg DM and hence an energy intake level at the lower end of the daily ME allowance for maintenance and live weight gain of cattle. Both results would suggest that camels have lower energy requirements and/or extract more from fibrous feeds. However, more field work is needed to determine the metabolisability of camels' diets and the energy costs of feeding and production to develop feed budgets within defined production patterns.

Key words: *Camelus dromedarius*, coarse feeds, supplements, intake, digestibility, feed requirements.

RESUME - "Besoins alimentaires chez le chameau". L'ingestion de matière sèche (MS), la digestibilité et l'utilisation de fourrage pauvre sont étudiées chez le dromadaire en stabulation. L'ingestion de MS du foin de pré, de la paille de blé et du foin d'avoine est respectivement de 0,92, 0,65 et 0,66 kg par 100 kg de poids vif. Avec ces types de fourrage, l'aptitude naturelle du dromadaire à sélectionner est faible et entraîne une réduction de l'ingestion même en cas de déshydratation limitée. L'ingestion augmente avec la complémentation. Elle est de plus 16% avec le foin d'avoine et de plus 60% pour

la paille de blé avec un complément riche en azote chez l'adulte. Chez le jeune en croissance, l'ingestion de paille de blé augmente, lorsque l'apport azoté s'accroît de 15 à 22% mais diminue au-dessus. La digestibilité de la matière sèche de la paille de blé et du foin de pré est respectivement de 44,8 et 55,9%. La digestibilité de la matière organique de la paille de blé augmente de plus 16%, avec un complément riche en azote, mais les digestibilités du NAF, de l'LADF et de la cellulose sont plus faibles que sans complémentation. L'énergie digestible de la paille de blé et du foin de pré est respectivement de 8 et 10 MJ par kg MS, avec une ration de base de paille de blé complémentée apportant approximativement 10,5 MJ d'énergie métabolisable par kg MS, une production laitière de 6 kg et une croissance corporelle de 140 g par jour sont obtenues avec des femelles laitières. De même, des jeunes dromadaires recevant un repas apportant environ 8,5 MJ d'énergie métabolisable par kg MS ont un GMQ de 285 g. Ces résultats indiquent que les dromadaires tirent plus d'énergie des parois végétales. Mais de nouvelles études sont nécessaires pour préciser l'utilisation métabolique des aliments par les dromadaires.

***Mots-clés** : Camelus dromedarius, fourrage grossier, supplément, ingestion, digestibilité, besoins alimentaires.*

Introduction

With few exceptions, camels are associated with nomadic or semi-nomadic production systems. However, these systems are undergoing rapid adaptive changes and transformations to cope with emerging demographic and economic factors (Hashi, 1991). Many herders are becoming more and more attached to quasi-permanent settlements. The resulting short-range management system differs considerably from the traditional long-range mobility patterns which used to balance the feed budgets of the herds. These included, for example, the exploitation of the camel's water turnover capacity by reducing the frequency of watering during the dry season and the driving of the herds to remote pastures. Another development in pastoral communities, is increasing cropping in very dry lands and the emergence of agropastoralism as a major production system.

A related trend within formerly purely pastoral systems, is the increasing commercialization of milk, and various forms of less mobile camel dairying are expanding. In some cases, producer-traders may keep lactating animals (taken from the main mobile herd) near settlements where they can regularly market the milk. On occasions, the milking herd has access to range enclosures or reserves around the settlements. At the extreme end of these trends, camels may be raised, on a permanent basis, in ranches or in agricultural areas (with access to fallow lands, stubble grazing and crop residues) and in and around urban centres where they are provided purchased feedstuffs.

Camel feeding management and strategies must take into account these incredibly complex production patterns based on different resources (in terms of feed and physical environment) and guided by different producer/production targets (increased milk production, prolonged lactation for subsistence, herd growth and stability, etc.).

Guidelines for camel feeding have often been extrapolated from the feeding standards for cattle, assuming that the digestibility of foods by camels and their efficiency of utilization of nutrients for various functions do not differ significantly from those of true ruminants (Bhattacharya *et al.*, 1988; Gihad *et al.*, 1989; King, 1983;

Wilson, 1989). The purpose of this paper is to provide a scientific assessment of some available feed resources and their utilization by the camel. Emphasis will be placed on the primary factors that influence the conversion of feed and forage to animal end products, i.e. dry matter intake (DMI) or energy intake, digestive capacity and the efficiency of utilization of feed. The paper is based on the research work (EEC STD II dromedary programme) carried out by the University of Pisa (Italy) and Ecole Supèrieure d'Agriculture in Mateur (Tunisia).

The animal component

Estimation of the factors influencing feed conversion, and the subsequent development of nutritional constants that can allow estimation of requirements for various productive functions, must take into account both animal and feed components of variations.

The first step must be to characterize the animal. Data on the camel is too limited to give a uniform and regular pattern. For milk volume yield and milk constituents, the review of the literature (Yagil, 1982) shows milk yields ranging from 735 to well over 5000 kg (calculated per 305 day), and fat and SNF contents of the ranges of 2.9-5.38% and 7.01-10.36% respectively. Data on mature size, rate of maturity and body composition at maturity is very scanty. Even the reproduction aspects which have been extensively studied show wide variations (Wilson, 1989): age at first parturition is, in general, in the region of 4-5 years but a range of 2 to over 6 years has been recorded; intervals between births are about or in excess of two years (in the range of 13 to 20 months); and lifetime production can extend to over 20 years. In addition to these attributes, the feeding behaviour of the camel, which is able to exploit a wider variety of plants and parts of plants compared to conventional ruminants, must be taken into account. Camels are considered to be browsers, but there are situations where they depend only on grazing. The wide animal and feed component variations indicate the difficulty of obtaining standard animals that can have minimal animal variations in food intake and digestive capacity.

Feed intake

Camel's feed intake depends primarily on its selective feeding of a wide variety of vegetation and different parts of forage browse which differ in quality. However, feed intake studies, often based on uniform standard diets, do not take into account that ability. As a matter of fact, the few feed intake values reported for the camel in its natural conditions, are superior to those obtained under stall-fed conditions. The DMI values for camels grazing natural pastures have been estimated to be 1.6-3.8 kg DM per 100 kg lw (Richard, 1989).

On the other hand, with conventional confined feeding trials, quite consistent and somewhat similar results have been obtained with a variety of different hays. In our studies (Cianci *et al.*, 1992), the voluntary intake of meadow hay was 0.92 kg DM per 100 kg lw and similar to that reported for a variety of different hays (Gerard and

Richard, 1989; Gihad *et al.*, 1989; Maloiy, 1972). These data showed that, under controlled feeding management, the intake of hays by the camel is generally restricted to less than 50 g DM per kg $lw^{0.75}$. Very much lower values have been obtained with more fibrous crop residues. Intake of wheat straw as the sole feed was 0.65 kg DM per 100 kg lw (corresponding to 32 g DM per kg $lw^{0.75}$) and that of oat hay was 0.66 kg DM per 100 kg lw. These data are summarised in Table 1a through 1d which report also the effects of some factors (such as watering frequency and supplementation) that influence the intake of fibrous feeds.

Table 1a. DMI (kg per 100 kg lw) of adult female camels offered low quality roughages (Cianci *et al.*, 1992; Kamoun *et al.*, 1992a; Kamoun *et al.*, 1992c; Orlandi *et al.*, 1992)

Wheat straw	Oat hay	Meadow hay	Wheat straw + High-CP (40%) supplement	Oat hay + concentrate*	Wheat straw + concentrate*
0.65	0.66	0.92	1.12	1.62	1.73

Table 1b. DMI (kg per 100 kg lw) of adult female camels at different watering regimes (Kamoun *et al.*, 1992a)

Days after	0		1		2		3		4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Straw	0.50	0.11	0.45	0.11	0.44	0.12	0.41	0.10	0.38	0.11
Concentrate*	0.36	0.03	0.36	0.03	0.36	0.03	0.36	0.03	0.36	0.03
Total	0.86	0.11	0.81	0.11	0.80	0.12	0.77	0.10	0.74	0.12

* Concentrate allowance of 2 kg per head per day

Table 1c. DMI (kg per 100 kg lw) of young growing camels offered straw at different levels of protein concentration (Kamoun *et al.*, 1992b)

	PL* 15.8		PL* 22.0		PL* 28.1	
	Mean	SD	Mean	SD	Mean	SD
Wheat straw	0.90	0.18	0.98	0.22	0.95	0.19
Total	1.35	0.20	1.44	0.21	1.42	0.21

* Protein level (%)

Table 1d. DMI (kg per 100 kg lw) of adult female camels performing various functions (Kamoun *et al.*, 1992c)

	Lactation		Early gestation		Dry	
	Mean	SD	Mean	SD	Mean	SD
Wheat straw	0.66	0.19	0.59	0.16	0.59	0.15
Concentrate	1.07	0.30	0.43	0.18	0.44	0.11
Total	1.73	0.44	1.02	0.26	1.03	0.19

Watering frequency

Environmental factors (thermal environment, level of dehydration, etc.) affect the intake capacity. The camel obtains most of its water requirements, for extended periods of time, from food selecting more succulent vegetation (Wilson, 1989). For this reason, together with its particular physiological characteristics, the camel is able to maintain appetite under conditions of dehydration.

When the basal feed resources are mostly straw and stovers and other low quality roughages, there is little opportunity for those capacities of selective browsing of succulent vegetation. And the camel may not tolerate restricted access to drinking water as may be the case under natural conditions. In an attempt to determine the effect of the frequency of watering on the voluntary intake of low quality roughages, adult female camels were offered wheat straw with concentrate supplementation (2 kg per head per day) and subjected to infrequent watering (Kamoun *et al.*, 1992a). There was a gradual reduction in roughage intake as the distance from the last watering date increased. The depression in wheat straw consumption after 5 days without water was up to 25% even with the concentrate supplementation (Table 1b). However, even in this case, the camel economised water use: daily water intake decreased from 60 ml per kg $lw^{0.82}$ when the non-lactating animals were watered daily to about 25 ml per kg $lw^{0.82}$ after 5 days of water deprivation. Nevertheless, the continued use of such poor quality roughages in camel feeding, calls for more frequent watering.

Supplementation

Consumption of low quality roughages and total feed intake by camels can be improved with supplementary feeding. The feeding trial that examined the effect of watering frequency on intake addressed also the extent to which this is improved through concentrate supplementation (Kamoun *et al.*, 1992a). The concentrate feeding resulted in a highly significant improvement (by as much as 16%) in oat hay consumption. However, total DMI of this species remained, in any case, limited (around 1.6 kg per 100 kg lw) even with high concentrate level (up to 50%) in the feeding regime. In a similar trial (Orlandi *et al.*, 1992), when adult camels with *ad libitum* access to wheat straw were offered a high-CP (40.9%) supplement, total DMI increased to 1 kg DM per 100 kg lw from just 0.6 kg DM per 100 kg lw for a non-supplemented treatment.

Results suggest that the maximal intake of the poor quality roughages as the sole feed is restricted probably due to nutrient deficiencies (such as N) or longer digestion rates. Concentrate supplements generally increase intake of poor low-protein roughages by virtue of their high protein content (ARC, 1980). In fact, cattle grazing or fed low quality roughages, are often supplemented with N or protein supplements (containing 20 to 40% CP) with positive effects on feed intake and utilisation. To verify this in camels, young growing camels (18 months old and average BW of 294 kg) were offered wheat straw as the basal feed and supplemented with concentrate feeds providing 15.8, 22.0 and 28.1% CP on a DM basis (Kamoun *et al.*, 1992b). DMI increased slightly from the first CP level to the second (1.3-1.4 kg DM per 100 kg lw) but remained the same or slightly decreased when the CP level was raised to 28% (Table 1c). For comparison, research with cattle has shown that forage intake reached a plateau when steers were fed supplements containing moderate (26%) to high (39%) concentrations of CP. When CP concentration was increased above 20% additional enhancement of forage seemed to occur but at a diminishing rate (Hannah *et al.*, 1991).

Physiological state

Prediction of DMI will have to take into account the physiological state of the animals. For the camel, data on how weight, production, days into lactation and lactation number, affect intake both under natural conditions and in stall-fed situations are limited. In addition, the camel's feed balance is further affected by the characteristically pronounced peak production and longer lactations and by the seasonal patterns (involving cyclic deficiencies) in feed availability.

In a feeding trial in which lactating, pregnant and dry dromedary camels were stall-fed and offered wheat straw *ad libitum* and daily concentrate rates of 5 kg per head during lactation and 2.5 kg in early gestation or when dry (Kamoun *et al.*, 1992c), total DMI of lactating animals (average BW 430 kg) was 1.73 kg DM per 100 kg lw (Table 1d). The DMI of animals at early/mid gestation was very close to that of dry animals (1 kg DM per 100 kg lw). The feed intake of the lactating camels was higher by about 70% compared to that of animals in early gestation or at maintenance. However, it was not possible with that study to ascertain how much of the increase could be related to the physiological status and/or to the differential concentrate allowance.

Digestive capacity

Data on the digestibility of forages and browses under natural and stall-fed conditions, are also limited. The variations, within the small number of observations made so far, are due to the factors (environmental, animal characteristics and feed quality and physical form) known to influence the two traits of food intake and digestibility.

The digestibility of food depends, among other factors, on the selective capacity of the animals and the efficiency of rumination and retention time. However, many of the digestibility trials do not address the characteristics of many tropical forages and

browse and do not allow enough refusal rates to accommodate that selective capacity (Van Soest, 1982).

In our studies (Cianci *et al.*, 1992; Orlandi *et al.*, 1992), attempts have been made to evaluate intake and digestibility of nutrients of various forage species and crop residues under stall-fed conditions. The digestibility coefficients of the examined feeds are shown in Table 2. DMD digestibilities of wheat straw and meadow hay were respectively 44.8 and 55.9%. CP digestibility of wheat straw was practically zero in accordance with that reported for the same feed in tables of the nutritive value of feeds (Andrieu *et al.*, 1988). The digestibility of the protein of hay was 53.0%. For NDF, ADF and cellulose digestibility mean values were similar for wheat straw and meadow hay.

Table 2. Apparent digestibility of some common feeds by the camel (Cianci *et al.*, 1992)

	Wheat straw	Meadow hay	Wheat straw + supplement*
DM	44.8	55.9	48.2
OM	48.0	58.2	52.0
CP	0.90	53.0	59.8
CF	57.3	59.6	57.7
NDF	53.3	52.4	49.1
ADF	50.0	51.0	41.0
Cellulose	60.8	61.7	57.9
Hemicellulose	51.3	55.4	67.4
Energy	46.6	57.2	52.4

* High-CP (40.9%) supplement

Integrating wheat straw with a high-CP supplement improved OM digestibility (52.0%) compared to that of a non-supplemented treatment (with OM digestibility of 44.8%). This, in addition to the value obtained for CP (59.8%) with the supplementation (CP digestibility was almost negative when straw was fed as the sole feed), are most likely related to the digestion of the supplement. However, the digestibility of NDF, ADF and cellulose did not follow the same trend and was lower than those of the non-supplemented group. Increased passage rate, that may be associated with the enhanced forage intake as a result of protein supplementation, may account for that difference. Depression in digestibility due to increased intake occurs even when forages are fed alone and this is mostly attributed to the depression in digestibility of cell wall fractions (Osbourn *et al.*, 1974).

The nutritional characteristics of some common basal feeds have been assessed from the digestibility trials. Table 3 reports the feeding values of wheat straw and meadow hays for adult camels (Cianci *et al.*, 1992; Orlandi *et al.*, 1992), together with that of lucerne hay and barley grain for young growing camels (Bhattacharya *et al.*, 1988).

Table 3. Nutritional characteristics of some common feeds (Bhattacharya *et al.*, 1988; Cianci *et al.*, 1992; Orlandi *et al.*, 1992)

	Straw	Meadow hay	Lucerne hay	Barley grain
DDM (g per kg DM)	448.1	559.1	518.0	751.3
DOM (g per kg DM)	439.1	531.5	504.7	762.0
DCP (g per kg DM)		38.7	108.0	73.0
DE (MJ per kg DM)	8.1	10.0	10.2	14.8
ME* (MJ per kg DM)	6.6	8.2	8.4	12.1

* ME calculated from measured digestible energy

Feed requirements

The development of feeding standards for the camel, is a very complex exercise given the wide ranging feeding conditions and the wide animal and feed component variations. The resource base is not well defined and the conceptualization of standard animals with minimal animal variations is not easy.

Attempts were made to evaluate responses of the camel to various diets formulated so that they would be appropriate for true ruminants. In the feeding trial with adult female camels performing various function and refered to earlier (Kamoun *et al.*, 1992c), the lactating camels had an average production of 6 litres and showed a positive live weight change (140 g per day). If it is assumed that the digestibility of foods by camels does not differ from those of true ruminants and using standard equations derived from cattle, the diet would contain approximately 10.5 MJ ME per kg. Taking into account DMI of about 1.73 kg DM per 100 kg lw, the energy intake of the lactating camels would be slightly less than that of lactating cows of the same weight range, milk production level and body weight change during lactation. It is interesting to note that, despite the high concentrate level (5 kg per day), the overall diet was still highly fibrous and provided 21, 24 and 50% CF, ADF and NDF respectively. Recommended nutrient content of rations for dairy cattle of similar production performance is 17% for CF and 21% for ADF.

In the trial with young growing camels provided wheat straw and 1.6 kg of concentrate per day (Kamoun *et al.*, 1992b), ADGs were 285 g. That ration would provide about 8.5 MJ ME per kg DM. With a total feed intake of 1.4 kg DM per 100 kg lw, the energy intake of the camels would be 35 MJ ME. This is at the lower end of the daily ME allowance for maintenance and live weight gain of cattle (ARC, 1980).

One may assume that the requirements of the camel are lower than those of other ruminants. The metabolisable energy requirements for maintenance (MEm) of the dromedary camel have been assumed to be lower and its efficiency of utilisation of ME for body tissue gain higher (Guerouali and Zina Filali, 1991). Camels are also faster and more efficient walkers and hence their energy cost of walking is also lower. Other works have suggested that the ME value of feeds for camels would be slightly higher than those measured in sheep, and camels generally extract more energy from the food they consume (Degan *et al.*, 1987).

At field conditions, many more factors and their variations affect the camel's feed economy. For instance, there are a number of factors (changes in metabolism, mobilisation of body tissue, changes in herd management, etc.) which try to reduce dry season effects and these have to be quantified to complete the feed budgets in real-life situations. Calculations of feed requirements for the camel still rely heavily on data and constants (requirements, metabolisability of diets, etc.) generated with cattle, and, therefore, more extra field work is needed before reliable feed budgets can be developed within defined production patterns. Only then, it will be possible to design solutions (i.e. supplementation) for the nutritional constraints that limit increased and sustained productivity.

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