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EFFECT OF DIETARY ENERGY AND PROTEIN ON NUTRIENT UTILIZATION BY SHEEP, GOATS AND CAMELS

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SUMMARY

Four rams, four bucks and three she-camels were used to study the effect of high or low dietary energy and protein and their interactions on nutrient intake , digestibilities , nitrogen balance and water in-output relationships. Animals were fed four rations, high energy-high protein (HH), high energy-low protein (HL), low energy-high protein (LH) and low energy- low protein (LL). The average TDN values were 63% (H) and 47% (L) and CP contents averaged about 17% (H) and 9% (L).

Camels compared to sheep and goats consumed less dry matter however, the TDN and DCP intakes were comparable among the three species. Camels showed significantly higher nutrient digestibilities than sheep or goats. Camels showed lower nitrogen intake, excretion and consequently higher nitrogen balance. Water intake and losses were lower by camels than sheep and goats.

Increasing dietary energy or protein increased dry matter intake, nutrient intake and digestibilities. Sheep and goats showed better response to high energy while camels were more responsive to the higher protein level. Nitrogen balances were improved by feeding high protein or high energy rations. Increasing dietary energy decreased water intake while it decreased by increasing dietary protein level. The improved effect of

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increasing either dietary energy or protein was more evident on the high level than on the other.

INTRODUCTION

Recent comparative nutritional studies among ruminant species have recently stirred a great interest in order to define a better feeding system for each species. This topic is of a real importance due to the limited feeding resources.

Sheep and goats were subjected to many comparative studies, while few experimental works with sound design and methodology on camel nutrition is available. Variable energy and protein as the two main nutrients in the ration were investigated in the present study.

The objective of the present study was to investigate and compare the response of each species to the combination of high and low energy and protein.

MATERIALS AND METHODS

Four Ossimi rams of 50 Kg body weight, four Baladi bucks of 25 Kg body weight and three female Mowalled camels of 300 Kg body weight were used in the study. Sheep and goats were individually kept in metabolic cages, while camels were housed in individual partitions of the barn of dimensions of 2x1 meters to facilitate feeding and total collection of feces and urine. Each metabolism trial lasted for 21 days preliminary period and 7 days for collection period.

Barley grain (IFN 4-00-549), soy-bean meal (IFN 5-20-637), berseem hay (IFN 1-01-340) and barley straw (IFN 1-00-498) were used to formulate the four experimental rations (Table 1). Animals were fed ad. lib. Fresh water was freely offered twice daily. Feed and water intakes were daily measured. Total collection of feces and urine of sheep and goats was carried out by the conventional method. However, feces from she camels were collected via a long harness tightly attached to their back and urine was collected through a plastic tube surgically inserted into the vulva. The detailed procedures were illustrated by El-Banna (1993). Composite samples of feeds, feces and urine were chemically analyzed according to A.O.A.C (1975) methods.

Data collected were statistically analyzed using the

GLM of SAS (1990) according to the following model :

X= M +S +E +P +ExP +SxE +SxP +SxExP +Error

where:M= overall mean, S= species effect, E= energy effect, P=protein effect, ExP energy-protein interaction, SxE species-energy interaction, SxP= species-protein interaction, SxExP= species-energy-protein interaction and Error= residual error.

RESULTS AND DISCUSSION

Composition of the experimental rations is presented in Table 1. Low energy rations, either high or low in protein content, were characterized by high crude fiber and ash and low NFE contents. Nutrient digestibilities

Table 1. Composition of the experimental rations

Item	Energy	High		Low	
	Protein	High	Low	High	Low
Ingredient,%					
Berseem hay		40	-	100	30
Barley straw		-	25	-	70
Barley grains		50	75	-	-
Soy-bean meal		10	-	-	-
Dry matter, %		90.25	91.70	89.00	91.80
DM composition,%					
OM		91.80	92.77	87.19	86.47
CP		17.16	9.35	16.85	8.18
CF		19.37	14.97	38.20	37.63
EE		1.92	1.60	2.02	1.19
NFE		53.35	66.85	30.12	39.47
Ash		8.20	7.23	12.81	13.53

Nutrient digestibilities of the experimental rations are presented in Table 2 (a and b) Camels showed higher (P=0.0001) digestibilities of DM, OM, CP, CF, EE (P=0.0029) and NFE (P=0.0093) than sheep or goats which showed almost comparable values. This might be related to the longer retention time of particles in the rumen of camels (Heller et al., 1986) and their more rapid frequency of forestomach contractions and rumination cycles, which could provide more mastication, mixing and absorption (Vallenas and Stevens 1971 a). Moreover, the more effective means of buffering short chain fatty acids produced by camels (Vallenas and Stevens 1971 b). The specific relationship between dry matter intake and nutrient digestibilities (Blaxter 1967) could be considered to clarify the higher digestibilities by camels having lower dry matter intake compared with sheep and goats (Table 3a).

Table 2a. Effect of dietary energy and protein levels on nutrient digestibility by sheep, goats and camels

Item	Energy	High		Low	
	Protein	High	Low	High	Low
DM (SE=0.97)					
Sheep		70.63b	61.17d	56.58e	56.71e
Goats		69.16bc	66.60c	57.73de	52.27e
Camels		82.89a	71.32b	60.94d	56.23e
OM (SE=0.87)					
Sheep		74.51b	66.32d	57.71fg	57.73fg
Goats		72.22bc	70.63c	57.18fg	55.80g
Camels		84.74a	75.47b	61.77e	59.61ef
CP (SE= 4.86)					
Sheep		71.80b	35.02d	54.89c	31.83de
Goats		71.64b	34.03d	53.70c	28.47e
Camels		83.91a	50.90c	55.28c	33.13de
CF(SE=7.18)					
Sheep		43.66e	28.51f	53.00cd	55.85bc
Goats		43.58e	30.35f	54.68c	55.44bc
Camels		67.44a	47.12de	62.39ab	57.97bc
EE (SE= 0.52)					
Sheep		68.76b	53.37d	54.40cd	40.87ef
Goats		68.79b	54.32cd	60.78cd	34.64f
Camels		77.45a	61.66bc	54.87cd	44.19e
NFE (3.81)					
Sheep		87.78ab	79.52c	65.48d	64.97d
Goats		82.93bc	85.16bc	63.72d	62.59d
Camels		91.54a	85.59b	65.07d	67.13d

a,b,c,d,e,f Means on the same rows or columns within each trait with unlike superscripts differ ($P<0.05$).

Table 2b. Analysis of variance of Table 2a

Source	Df	Digestibilities of DM	OM	CP	CF	EE	NFE
Species (S)	2	.0001	.0001	.0001	.0001	.0029	.0093
Energy (E)	1	.0001	.0001	.0001	.0001	.0001	.0001
Protein (P)	1	.0001	.0001	.0001	.0001	.0001	.0635
ExP	1	.0001	.0001	.0001	.0001	.5073	.0468
SxE	2	.0001	.0003	.0001	.0001	.0724	.1341
SxP	2	.0067	.0170	.1519	.0384	.0385	.1123
SxExP	2	.0068	.0092	.7480	.3888	.0134	.0266

Table 3a. Effect of dietary energy and protein levels on dry matter and nutrient intakes (g/Kg$^{0.75}$) by sheep, goats and camels

Item	Energy / Protein	High / High	High / Low	Low / High	Low / Low
		DM (SE=3.23)			
Sheep		78.1b	65.8bc	51.6de	40.9ef
Goats		91.8a	78.5b	37.8f	45.4def
Camels		69.0b	53.3cd	55.6cd	35.6f
		TDN (SE= 3.68)			
Sheep		54.8a	41.2bc	26.6de	20.8de
Goats		62.4a	51.7ab	19.5de	22.2de
Camels		55.4a	37.9c	31.1cd	18.6e
		DCP (SE=0.95)			
Sheep		9.62b	2.16d	4.76c	1.05e
Goats		11.29a	2.47d	3.42d	1.06e
Camels		10.01b	2.54d	5.32c	0.96e

a,b,c,d,e,f Means on the same rows or columns within each trait with unlike superscripts differ (P<0.05).

Table 3b. Analysis of variance of Table 3a

Source	df	Intake g/Kg$^{0.75}$ DM	TDN	DCP
Species (S)	2	.0027	.1584	.4190
Energy (E)	1	.0001	.0001	.0001
Protein (P)	1	.0001	.0001	.0001
ExP	1	.1393	.0169	.0001
SxE	2	.0001	.0085	.0011
SxP	2	.0206	.0983	.7419
SxExP	2	.0463	.6287	.0022

Increasing dietary energy decreased (P=0.0001) CF digestibility but increased (P=0.0001) the other nutrient digestibilities. The lower CF but higher CP digestibilities associated with feeding high energy rations might be related to barley acting as a readily fermentable carbohydrate and inhibits cellulose digestion. However, it stimulates the yield of microbial protein through increasing the capture of nitrogen by rumen microbes (Chase and Hibberd 1987).

Increasing dietary protein significantly increased nutrient digestibilities. The improved effect of high protein on nutrient digestibilities was more distinct when high energy rations were fed specially in case of DM, OM, CP, CF and NFE digestibilities. The energy x protein interaction on these nutrient digestibilities were significant. This result was in line with the findings of Yilal and Bryant 1985 that the improving effect of increasing either dietary energy or protein concentration on nutrient digestibilities depends on the availability of each other.

The three species showed comparable response in EE and NFE digestibilities by feeding high energy rations and in CP and NFE by feeding high protein level since these interactions were not significant (Table 2b). However, camels showed higher response in the digestibility of DM and CF than sheep or goats by feeding high protein rations. Meanwhile, sheep and goats showed better response to high protein ration to increase the digestibility. This result might indicate that the nutrient digestibility is much affected by protein in rations of camels.
However, sheep and goats were more sensitive to dietary energy.

Intake

Dry matter and nutrient intake (g/Kg $W^{0.75}$) are presented in Table 3 (a and b). Sheep and goats consumed comparably higher (P=0.0027) DM than camels. However, no significant differences in TDN or DCP intake was found among the three species because of the high nutrient utilization by camels. Therefore, camels may achieve comparable energy and digestible protein intakes through their lower dry matter intake. This could be considered as one of the advantages of camels over sheep and goats. This observation was in agreement with that found by Gihad et al. (1989). The relative low dry matter intake by camels might be related to their relative small rumen volume as a percentage of body weight (Ghosal et al., 1981) and the longer retention time of feed particles in their digestive tract (Lechner-Doll, 1986), where there is a negative curvilinear relationship between retention time and dry matter intake (Faichney and Gherardi, 1986).

Increasing dietary energy or protein increased (P=0.0001) DM, TDN, and DCP intakes. The improved effect of high dietary energy concentration on feed intake may be related to high dietary energy causing improved nutrient digestibilities and increased digesta passage which enhances feed intake (Lu and Potchobia 1990).

However, the improved effect of high dietary protein on feed intake level may be related to the correction in the balance between energy and protein (Egan 1977). Energy x protein interaction was not significant on DMI but significant for TDNI (P=0.0169) and DCPI (P=0.0001).

Camels compared to sheep and goats showed the lowest response to increase nutrient intake by feeding high energy rations. On the other hand, camels showed highest response in dry matter intake high protein rations. This result was confirmed by the high correlation between DM and TDN intakes by sheep (r= 0.8258) and goats (r=0.9142) and low correlation by camels (r=0.7093). The opposite trend was found in the relationship between DM and DCP intake, where high correlation was found by camels (r= 0.7809) and lower correlation by sheep (r=.6048) and goats (r=0.4539). This result may indicate again the higher response of camels to dietary protein and the higher response of sheep and goats to dietary energy.

Nitrogen balance

Camels showed lower nitrogen intake than sheep or goats because of their lower voluntary dry matter intake (Table 3 a,b). Nevertheless, no differences were found in the nitrogen balance among the three species. Sheep and goats significantly excreted more nitrogen in feces (P=0.0001). Urinary-N excretion by camels was insignificantly less (P=.2889) than sheep and goats. Accordingly, the tota nitrogen outflow by camels showed the lowest (P=.0001) values. Therefore, the nitrogen balance values by camels were better than those by sheep or goats. This result may confirm again that camels are more efficient in dietary protein utilization than sheep and goats. Herein results were in line with those of Gihad et al. (1989). They found that camels consumed less nitrogen, excreted less nitrogen in urine, but more nitrogen in feces and utilized nitrogen better than sheep and goats.

Increasing dietary energy or protein resulted in significantly higher nitrogen intake, fecal-N, urinary-N excretion, and nitrogen balance. The increase in retained nitrogen in spite of the increase in nitrogen losses may be due to the improving effect of high dietary energy and protein on nitrogen utilization (Solaiman et al., 1990).

Dietary energy was the most determinant factor for nitrogen utilization by sheep and goats. However, camels were more sensitive for dietary protein as indicated from Table 4 (a and b). This trend was previously found for intake and digestibility (Table 2 a and 3a).

Table 4a. Effect of dieteray energy and protein levels on nitrogen balance (g/Kg$^{0.75}$) by sheep, goats and camels

Item	Energy	High		Low	
	Protein	High	Low	High	Low
Intake (SE=0.07)					
Sheep		2.14b	0.99ef	1.39cd	0.54gh
Goats		2.52a	1.16de	1.02ef	0.60gh
Camels		1.91b	0.80fg	1.50c	0.47h
Fecal loss (SE=0.03)					
Sheep		0.61b	0.65ab	0.63ab	0.37cd
Goats		0.71ab	0.76a	0.47c	0.43cd
Camels		0.31d	0.39cd	0.65ab	0.31d
Urinary loss (SE=0.04)					
Sheep		0.87a	0.31cd	0.59b	0.33cd
Goats		0.84a	0.29d	0.430bcd	0.51bc
Camels		0.60b	0.27d	0.51bc	0.49bcd
Total outgo (SE=0.06)					
Sheep		1.48a	0.96cde	1.22b	0.70ef
Goats		1.55a	1.05bcd	0.90cdef	0.94cde
Camels		0.91cdef	0.66f	1.16bc	0.80def
Balance (SE=0.06)					
Sheep		0.66b	0.03de	0.17cd	-0.16ef
Goats		0.97a	0.11cd	0.12cd	-0.34f
Camels		1.00a	0.14cd	0.34c	-0.33f

a,b,c,d,e,f Means on the same rows or columns within each trait with unlike superscripts differ (P<0.05).

Table 4b. Analysis of variance of Table 4a

Source	df	Nitrogen Intake	Fecal	Urine	Outgo	Balance
Species (S)	2	.0296	.0001	.2889	.0001	.0630
Energy (E)	1	.0001	.0001	.0909	.0001	.0001
Protein (P)	1	.0001	.0004	.0001	.0001	.0001
ExP	1	.0001	.0001	.0001	.0626	.0004
SxE	2	.0001	.0001	.0410	.0001	.0026
SxP	2	.2661	.0211	.0082	.0076	.0081
SxExP	2	.0010	.0079	.0275	.0023	.5796

Water input and output

Camels showed lower water intake (P=0.0001), fecal water loss (P=0.0019) urinary water loss (P=0.0003) than sheep and goats. Insensible water loss was also low (P=0.0001). Moreover, water intake and insensible water loss by sheep was significantly higher than goats. The low water intake and the fecal water loss by camels might be due to the fact that camels consumed less dry matter but the low urinary water loss might be related to the low water intake (Gihad et al., 1989) and/or the low glomerular filtration rate and high tubular re-absorption (Maloiy 1972) by camels. Moreover, it was reported that camels are able to regulate their body temperature through the change in body temperature by about ±6°C. This mechanism can save water loss through evaporation of sweat (Schmidt-Nielsen 1978).

Table 5. Effect of dietary energy and protein levels on water input and output (ml/Kg $W^{0.82}$) by sheep, goats and camels

Item	Energy / Protein	High: High	High: Low	Low: High	Low: Low
Intake					
Sheep		190.8b	109.9c	322.3a	114.4c
Goats		181.6a	106.4b	168.1a	144.6a
camels		78.5b	56.1b	156.8a	67.2b
Fecal loss					
Sheep		53.8a	50.2a	25.1b	38.8ab
Goats		49.4a	37.3ab	13.5b	29.8ab
Camels		18.2b	17.9b	26.2a	19.0b
Urinary loss					
Sheep		69.5b	20.8c	96.1a	51.2ab
Goats		58.2b	20.4c	63.1b	89.4a
camels		25.3b	18.0b	41.8a	26.5b
Insensible loss					
Sheep		67.5b	38.9c	201.2a	24.4c
Goats		74.0a	48.7b	91.5a	25.4c
Camels		35.0b	20.2b	88.8a	21.7b

a,b,c Means on the same rows or columns within each trait with unlike superscripts differ (P<0.05).

Table 5b. Analysis of variance of Table 5

Source	df	water intake	Water loss: Fecal	Water loss: Urinary	Water loss: Insensible
Species (S)	2	.0001	.0019	.0003	.0001
Energy (E)	1	.0001	.0083	.0001	.0001
Protein (P)	1	.0001	.7944	.0009	.0001
ExP	1	.0023	.1467	.0933	.0001
SxE	2	.0065	.0537	.2710	.0001
SxP	2	.0001	.7238	.0079	.0001
SxExP	2	.0001	.3026	.0332	.0001

Increasing energy intake decreased water intake, urinary and insensible water losses. However, increasing dietary protein increased these parameters. Urinary water loss was found to be positively correlated with nitrogen intake (Reynolds 1983). Moreover, Waghorn et al. (1990) found that insensible water loss increased with the high intake level from high protein diets which differed in energy content. The excessive intake from nitrogenous compounds would result in considerable water loss in the elimination of nitrogen end products (Scott 1981). The present results confirmed that high dietary protein significantly increased the intake and urinary loss and insensible loss of water (Table 5b).

Energy x protein interaction had no significant effect on fecal or urinary water losses. However, water intake and insensible water loss increased by feeding high protein specially when low energy rations were fed.

Water intake and insensible water loss by goats were less affected by dietary energy level. However, the three species showed comparable response to decrease their water losses in feces and urine by increasing dietary energy level.

The high water intake, high urinary and insensible water losses associated with the increase in dietary protein level were more evident for sheep and camels than goats. However, the interaction between species and dietary protein was not significant on fecal water loss.

It could be concluded that 1) camels showed an economic usage of feeds, water and nitrogen as indicated from their low intakes and low losses in comparison with sheep and goats, 2) improving caloric value or protein content of the rations improved the nutrient utilization by sheep, goats and camels. This improvement was associated with the higher dietary protein by camels but with higher dietary energy by sheep or goats and 3) the improving effect of high dietary energy or protein on intake and nutrient utilization depended on the availability of the other.

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تأثير طاقة و بروتين الغذاء على الإستفادة الغذائية للغنم والماعز و الإبل

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أجريت هذه التجربة على أربعه كباش وأربعه جداء وثلاث نوق لدراسة تأثير مستوى طاقة وبروتين العليقة وتداخلاتهما على المأكول ومعاملات هضم المركبات الغذائية وميزانى النيتروجين و الماء. غذيت الحيوانات على أربع علائق كما يلى :
١- عالية الطاقة - عالية البروتين ٢- عالية الطاقة - منخفضة البروتين ٣- منخفضة الطاقة - عالية البروتين ٤- منخفضة الطاقة - منخفضة البروتين. وكان متوسط القيمة الغذائية للعلائق عالية الطاقة ٦٣٪ ومنخفضة الطاقة ٤٧٪ مركبات مهضومه كليه(م م ك) أما المستوى العالى من البروتين فكان ١٧٪ والمنخفض ٩٪ بروتين خام.

أظهرت النتائج أن الإبل برغم أنها أقل إستهلاكا للغذاء إلا أنها تحقق نفس المأكول كقيمة غذائية مقارنة بالغنم و الماعز، ويرجع ذلك الى أن الإبل أظهرت معاملات هضم للمركبات الغذائية المختلفة أعلى من الغنم والماعز، وأيضا حققت الإبل ميزان نيتروجين موجب أعلى من الغنم والماعز بالرغم من إنخفاض المأكول من النيتروجين وهذا راجع الى إفرازها الأقل للنيتروجين فى الروث و البول، ونفس الإتجاه فى الماء فقد كانت الإبل أقل إستهلاكا وفقدا للماء.

أدت زيادة طاقة أوبروتين العليقة الى تحسن فى المأكول الإختيارى من المادة الجافة ومعاملات هضم المركبات الغذائية . و أظهرت الأغنام و الماعز أستجابة موجبة لمستوى الطاقة فى العليقة أعلى من الإبل بينما كانت الإبل أكثر حساسية لمستوى البروتين فى العليقة. وأظهرت نتائج ميزان النيتروجين تحسنا فى إحتجاز النيتروجين بزيادة كل من طاقة وبروتين العليقة. أما من ناحية لإستهلاك ماء الشرب فقد أدت زيادة بروتين العليقة الى زيادة فى إإستهلاكها والعكس بالنسبة للطاقة.

وقد أظهرت النتائج أيضا بوجه عام أن التأثير الموجب لأى من طاقة أوبروتين الغذاء على المقاييس التى تحسنت بزيادة يتوقف على توافر المستوى الأعلى للآخر.