EFFECT OF LEVELS OF DIETARY ENERGY AND PROTEIN ON SUDAN DESERT LAMB FATTENING

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Dedication

To my parents
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1. Introduction

The Sudan possesses an animal population of above 57 million head of cattle, sheep, goats, and camels. For this great potential resources of livestock as well as the availability of grazing lands, the Sudan can contribute greatly towards the alleviation of the present world deficit in animal protein. The recent estimates of the Ministry of Animal Resources (1986) indicated that sheep population in the Sudan is about 20.0 million head. Two thirds of this population are sheep of desert ecotype and the rest include Niletic, Arid Upland, Arid Equatoria, West African Fulani and many crosses between these ecotype (McClurey 1981).

Sudan desert sheep are herded by nomads in the non-riverine areas, depending mainly on natural range that have low nutritive value for the major part of the year and get scarce as the dry season of the year progresses. Even with this great lack in both quantity and quality of the natural pasture, nomads never used to supplement what the animal grazed from the pasture.

In most of the feedlots in the country, where concentrate supplementation is practised, the fattening ration used consist mainly of sorghum grains and cotton seed cake in the ratio 1:1, as reported by El-Hag and Hamad (1982). Although such ration provides energy and protein levels more than the required by animal, it is too expensive to be feasible. In
addition, feeding grains to ruminants will place them in direct competition with man and poultry. These problems directed feedlot operators and sedentary village based livestock owners to search for other feed sources such as agroindustrial byproducts and crop residues and supplement them with the nutrients of which they are deficient including energy and protein.

Animal owners in the Sudan have a limited knowledge of the different requirements of the various classes of animals for different nutrient to allow for a level of production that will fully express their genetic potential. The formulation of livestock diets in the Sudan is based on information and data from temperate regions. Since these data may not necessarily apply in the Sudan for its warm environment, studies on the nutrient requirement of livestock in the Sudan are needed, so that better regimes can be adopted.

In all types of animal production systems energy is quantitatively the most important item of the diet and all feeding standards are based on its need. Whereas protein, the critical nutrient for young growing animals, is the most expensive part of the feed. So its optimum use is necessary.

The objectives of this research is to examine the effect of levels of digestible energy and protein on Sudan desert lamb fattening.


. Literature Review

2.1 Sudan Desert Sheep:

Sudan desert sheep constitute 63% of sheep population in the Sudan. They occupy the arid and semi-arid areas (between the northern frontier with Egypt in the north and 12-14 north latitude in the south, and between 25° to 37° east longitude except the Libian and Nubian desert where vegetation is virtually absent.

McLeroy (1961) and Atabani (1963) reported that Sudan desert sheep ecotype is subdivided into many tribal breeds according to their owners and location in the region of the Sudan. They are Kababish, Meidob, Sutara, Gezira, Watish and North riverine woolly sheep. These tribal breeds differ a little bit in their phenotypic characteristics and colour.

Generally they are deep bodied, haired except the riverine woolly and Meidob breeds which possess a heavy mixed hair and wool coat. Desert sheep are long legged, have bold heads with pendulous ears that often hang below the head. The average length of ears is variable and ranges between 6-7 inches in Kababish and 3-4 inches in North riverine breed. Desert sheep height ranges between 34-36 inches in the Kababish and 26-27 inches in Reja breed. The tail is long thick and tapering. Usually the length of the tail is not less
than 70% of the wither height and may reach the ground in the Kababian breed.

Colour is not a characteristic feature, however, the typical Sudan desert is brown shading to white on the underside of the body, but white with brown marking and white with black marking is also common.

2.2 Performance of Sudan desert sheep:

Omar et al. (1968) reported that Sudan desert sheep performance was comparable to that of feeder lambs in U.S.A. and was better than the performance of Pakistani sheep. They reported that desert rams gained in the average 213, 251 and 195 g/day and desert wethers gained 188,192 and 152 g/day when fed 3 rations of different levels of dura and berseem. The feed consumption of these rams was 1.40, 1.29 and 1.39 kg/day, whereas feed intake of wethers was 1.33, 1.31 and 1.42 kg/day. The feed conversion ratio of rams were 6.57, 5.14 and 7.13 kg of intake/kg of gain/day and of wethers were .07, 6.82 and 5.34 kg of feed/kg of gain.

Nasim and Bollom (1983) reported that Sudan desert sheep have a favourable response to fattening in feed-lots directly after weaning. They fed sheep of desert type a ration containing 19.25% crude protein (CP) and 11.3% crude fibre (CF) in the dry matter (DM). The average daily gain was found to be 227.2 g/day and the average daily feed intake was
1.6 kg/day, whereas the feed conversion ratio was found to be 5.4 kg feed intake/kg weight gain. They also suggested that observed high rates of body weight gain could be associated with compensatory growth resulting from stress related to the early weaning of the experimental lambs (weaned at 4 months). Nanceur (1987) studied the effect of supplementation with blood meal on Sudan desert sheep performance. He reported an average daily gain of 123 g/day for the diet of 16.1% CP content, a feed intake of 1.13 kg/day and a feed conversion ratio of 5.8 kg feed intake/kg weight gain. Wilson (1976) reported the live weight gain of Sudan desert sheep under natural grazing conditions to be 82 g/day.

2.3 Effect of dietary energy level on animal performance and nutrient utilization:

2.3.1 Effect of dietary energy level on animal performance:

Performance of fattening animals is expressed in terms of amount of feed consumed/day, rate of body weight gain/day and feed conversion ratio which is the ratio of feed consumed to rate of body weight gain. These three parameters are very much correlated and are affected by many factors. The most important among these factors are feed quality and gastrointestinal capacity. The most critical item that influences feed quality is its digestible energy density and protein contents.
Khalifa (1971) reported that the voluntary intake of roughages was limited by the capacity of the rumen and the fill-in effect of the food at the end of a meal when the digestibility of the feed ranged between 50 to 70%. Over this range of digestibility a linear relationship was found between voluntary intake and quality of roughage. Maxwell et al. (1981) found that the increase in feed intake and weight gain was rapid when the digestibility of energy increased from 38% to 70% and thereafter the feed intake and weight gain increased more slowly. Cullough (1974) reported that feed consumption was limited by rumen fill or bulk as long as energy digestibility was below 60-63%. He suggested that above this range of digestibility feed consumption was influenced by the rations' energy density.

Andrews et al. (1969) fed lambs 5 rations of different metabolizable energy (ME) concentration. The rations contents of ME/kg dry matter (DM) ranged between 2.9 Mcal for diet A and 2.5 Mcal for diet E. They found that voluntary feed consumption increased as ME concentration decreased with little or no detrimental effect on growth rate. They suggested that the level of digestible energy content of the diet restricted voluntary feed consumption when the physical limitation of the gastrointestinal capacity and dental development of lambs, were alleviated. Mohamed (1986) fed Sudan Desert lambs with diets containing 9.8, 11.0 and 13.2 MJ/kg DM digestible energy (DE) and 17.0%CP. He found that voluntary feed
Consumption decreased significantly (P<0.05) above and below 11.0 MJ DE/kg DM. The daily intake of digestible energy by lambs receiving 13.3 and 11.0 MJ DE/kg DM diets were not different but were significantly (P<0.05) higher than that ingested by lambs fed the 9.8 MJDE/kgDM diet. He also found that lambs fed the later diet gained and utilized feed at slower and poorer rates than those offered the former diets. He concluded that lambs ate to maintain a constant digestible energy consumption. In their attempt to do so, the lambs receiving the least DE diet (9.8 MJ DE/kg DM) were limited by the space filling characteristics of that diet which contained 29% CF in the DM. He observed that lambs offered the 9.3 MJDE/kg DM diet consumed less feed than those offered the 11.0 MJDE/kgDM. However, both groups consumed the same amount of digestible energy. He suggested that the slower rate of body weight gain observed with the 13.3 MJDE/kgDM diet group compared to that of the 11.0 MJDE/kgDM diet group could be due to reduced intake of nutrients other than energy including protein.

Pollett and Almed (1979) used molasses as a source of energy in sheep isonitrogenous diets. They found that the diet containing 30% molasses and 8.49 MJME/kg DM produced the best live-weight gain whereas the diet of 60% molasses and 10.29 MJME/kgDM produced inferior weight gain compared to other groups. Diets of 15% and 45% molasses level and 7.71 and 9.34 MJME/kgDM respectively were intermediate. The same
40% molasses significantly decreased feed consumption. Macle- 
tar and Osman (1968) found that feeding 10, 20 and 30% 
molasses levels as a replacement of dried lubia to growing 
heifers did not improve average daily gain. The feed required 
to produce one kg of gain was in favour of the control group 
which had no molasses in its diet. However, the daily feed 
consumption tended to increase with the 10% molasses diet.

Elliott and Topp (1963 b) found that cattle receiving a 
low energy diet (47.5% TDN) consumed significantly less feed 
than those receiving high energy diet (65.3% TDN). This dif-
ference was associated with a significantly higher consump-
tion of digestible crude protein with the latter group. They 
also observed that cattle on the high energy ration gained 
weight whereas those on the low energy ration lost weight. 
They suggested that the possibility of protein sparing effect 
of energy rich diets could adequately account for the large 
difference in the performance of cattle given the two 
rations.

2.3.2 Effect of dietary energy level on nutrients diges-
tion and utilization :-

Digestion trails are important in the field of animal
nutrition for determination of the feeding value of the feed.
Many factors have been found to affect the rate of digestion of diets. The most important of these are energy density and protein content of the diet.

Stone and Fontenot (1965) and El-Hag and Mukhtar (1978) found that the digestibilities of dry matter, organic matter, energy and nitrogen free extracts were increased with increasing the level of available energy as concentrates. The same results were observed by Chappell and Fontenot (1968), except that here the differences were not always significant for the dry matter and energy digestibilities. Moreover, Osman (1985) found that addition of molasses increased digestibilities of dry matter, organic matter and nitrogen free extracts. Similarly Andrews et al. (1969) found a highly significant decrease on dry matter and energy digestibilities when the metabolizable energy (ME) concentration of the diet was decreased from 2.9 to 1.5 Mcal ME/kgDM. On the contrary Martin and Wing (1968) found that the digestibility of dry matter and energy were lower for molasses containing diets than for the molasses free diet.

The apparent digestibilities of crude protein and ether extracts were not influenced significantly by the available energy concentration as reported by Stone and Fontenot (1965). Moreover, El-Hag and Mukhtar (1978) found that ether extract digestibility data varied considerably. This varia-
tions was not due to the different concentrate to roughage ratios. However, El Samman et. al. (1971) reported that energy concentration was an important factor limiting protein utilization by growing sheep, whereas, Osman (1985) reported that the higher the energy content of the ration the greater was the digestibility of fat.

Crude fibre digestibility decreased with increasing available energy concentration of the diet (Stone and Fontenot, 1965; Martin and Wing, 1966; Chappell and Fontenot, 1966; El-Hag and Mukhtar, 1978; and Osman; 1985). They suggested that the observed decrease in crude fibre digestibility could be attributed to the preference of rumen microorganisms to the easily fermentable soluble carbohydrate rather than the less digestible crude fibre.

Osman (1985) found that the addition of molasses to cowpea straw considerably improved its total digestible nutrients (TDN) value from 63.1% to 67.2%. The observed increment in the traditional fattening ration had a significantly higher TDN value than the other examined rations because of its high energy component, the dura grains. Similarly Stone and Fontenot (1965) reported that the digestible energy and the TDN values increased with increasing energy level of the diet.

2.3.3 Effect of dietary energy level on nitrogen balance;

Nitrogen intake was related significantly to the daily voluntary intake of feed as reported by Osman (1985). His
results as well as those of Smith and Proctor (1977) and Elliott and Toops (1965) suggest that fecal and urinary nitrogen excretion were increased with low energy diets.

Chappell and Fontenot (1968) reported that the daily fecal nitrogen excreted did not differ among diets, whereas the urinary nitrogen which was double the amount of fecal nitrogen, decreased as the level of energy supplemented in the diet increased. Similar results have been reported by Osman (1985), Fick et al. (1973), Fontenot et al. (1955) and Ellis and Pfenner (1958). However, Fick et al. (1973) observed an opposite trend in another trial.

Nitrogen retained (g/day or as % of nitrogen intake) was found to increase with increasing energy level in the diet as reported by Osman (1985) and Fick et al. (1973). Forbes and Robinson (1969) reported similar results with higher levels of feeding. Singh and Mahadevan (1970) reported that diets containing adequate amounts of readily fermentable carbohydrate resulted in a low production of ruminal ammonia and greater nitrogen retention.

Stone and Fontenot (1965) observed that increasing available energy concentration had no effect on nitrogen retention. The small increase in nitrogen retention observed could be possibly due to the small increase in nitrogen intake when the medium energy ration was fed. Similarly Davis (1966)
observed that the diet of energy level 3497 kcal/kg DM, the lowest energy level than the other two diets of 3638 and 3741 kcal/kg DM had significantly better daily nitrogen retention than the others. This was entirely due to the greater utilization of digested nitrogen which was reflected in a significantly lower urinary nitrogen output.

2.4 Effect of dietary protein level on animal performance and nutrients utilization:

2.4.1 Effect of dietary protein level on animal performance:

Protein level in the diet was found to be of important effects on animal performance. Weston (1967) suggested that dietary protein was a primary factor limiting the voluntary feed consumption. He observed that raising the level of protein from 7 to 15% in a diet of lambs resulted in increased consumption of feed and subsequently increased consumption of ha and crude fibre. Elliott and Topps (1963 c) found that voluntary consumption of low protein diets by sheep increased significantly with increasing protein level of the diet. They observed that feed consumption increased linearly with the protein content of the diet to 8% CP level in group A and 6% CP level in group B. They further noted that beyond these protein levels the increase in feed consumption was no longer linear. Robinson and Forbes (1970) found that voluntary feed consumption and weight gain of sheep were significantly lower for 7.3% CP diet than for 11.3 and 19.0% CP diets. They
suggested that the lower weight gain of sheep fed the former diet may be due to the reduced energy input. This assumption did not appear to apply to the difference between the latter diets in which a greater difference in digestible organic matter intake resulted in a nonsignificant increase in liveweight gain.

Vipond et al. (1962) found that ewes ate significantly more straw when supplemented with soybean meal (48% CP) than when supplemented with barley (13% CP). Soybean meal supplementation resulted in a total liveweight gain of 2.16 kg in early lactating ewes compared with a loss of 2.53 kg by the barley supplemented group. The same results were observed with cattle by Greathouse et al. (1974). They found that steers fed the lower protein diet (sorghum grain) did not consume sufficient amount of feed to meet their protein requirements so they gained less than that of the higher crude protein containing ration (soybean meal). Steers fed soybean supplemented diets were significantly more efficient in feed conversion to body weight than those fed the sorghum grain diet.

Egan (1965 a) reported an improvement in the nitrogen status of sheep when duodenally infused with nitrogen. This resulted in an immediate transient increase in voluntary feed consumption which was not related to changes in the rate of digestion in the rumen. The increase of protein absorption
could be viewed as a possible component of a chemoregulatory mechanism governing the intake of roughages of low nitrogen content by sheep. Egan (1965b) suggested that the deficiency of protein may be a primary factor in limiting the dry matter intake of low protein roughages.

Hassan and Bryant (1986a) conducted a 2x2 factorial experiment of 2 different forages to concentrate ratio with or without fishmeal supplementation. The ME concentration was similar in all rations, whereas the nitrogen content differed. The nitrogen content were 18.6 and 19.7 g/kg for the diets not supplemented with fishmeal and were 24.2 and 25.3 g/kg for the fishmeal supplemented diets. They found that dry matter intake increased insignificantly with the fishmeal supplementation. There were no differences in digestible organic matter and ME consumption. Lambs given fishmeal gained faster and had a lower feed intake to weight gain ratio than the unsupplemented group. Lambs given high forage diets gained faster than those on the high concentrate diets. Sarif and Menke (1970) examined rations for the effect of level and source of protein on sheep performance. The basal diet contained 98 g/kg CP. The treatment diets consisted of diets of approximately similar protein contents but varied in the source of the protein. The protein sources employed were urea, rumovite and cotton seed cake. The protein contents were 138, 128 and 149 g/kg DM for the supplemented ration respectively. The results indicated that the level of protein
had a significant effect on average daily weight gain (control vs treatments) but the source of protein had no effect on the rate of growth (urea vs rumensite vs cotton seed cake). They also suggested that the higher susceptibility to pathogenic infection in the control group could be attributed to the low level of dietary protein. Similar results were reported by Osman et al. (1963) when they fed Sudan desert sheep 3 rations of different duration each to per cent ratios of which the protein content were 13.8, 12.5 and 14.6% of DM. These ratios had no effect on weight gain, feed consumption or feed conversion ratio for rams and wethers.

Repton (1971) found that lambs fed pelleted diets different in crude protein level gained slightly higher with the high protein diet (19.1% CP of DM) than with medium protein diet (15.8% CP of DM). However, both diets promoted significantly higher body weight gain rate than the low protein diet (11.7% CP of DM). Voluntary feed consumption and the efficiency of feed utilization showed the same trend. He concluded that 15 g DCP flow in the intestine /100g digestible organic matter was adequate for expression of maximum body weight gain and feed consumption and that was equivalent to, 15% CP in the diet. These results are in agreement with those of Hinds et al. (1964), Kay et al. (1969) and Kaiser et al. (1962). Hinds et al. (1961) found that increasing the level of protein from 13.0 to 16.2% and from 15.4 to 15.4% of DM in the diets resulted in a highly significant increase in
liveweight gain and reduction in feed required per pound of gain. Further increase in level of protein to reach 21.5% CP of DM, increased weight gain but nonsignificantly. Ray et al. (1968) offered steers, isocaloric diets containing different levels of crude protein. They found that there was no significant differences in either dry matter consumption or liveweight gain between steers given diets containing 14 or 17% CP of DM. However, dry matter consumption and liveweight gain were significantly lower for steers offered the diet containing 11% CP of DM. Kaiser et al. (1982) fed calves formaldehyde-treated maize silage supplemented with nitrogen sources to increase the total nitrogen from 13.2 to 31.4 g/kg DM with groundnut meal in one treatment and to 116.6 g/kg DM with fishmeal in another treatment. They found that protein supplementation significantly increased digestible organic matter, digestible energy and total dry matter consumption. However, the increase was not significant when groundnut meal diet was compared with fishmeal diet. Liveweight gain and feed conversion ratio were improved by protein supplementation. The margin of improvement of feed conversion ratio was superior with the fishmeal diet.

Mansour (1987) fed Sudan desert sheep 3 isocaloric diets (12.0 MJ ME/kg DM) supplemented with different levels of blood meal. The crude protein levels of the 3 rations were 13.3, 16.1 and 19.0% of DM. He found that the group of lambs fed the diet containing 16.14 CP of DM consumed more feed
than the other groups. This explains the better daily weight gain and feed conversion ratio observed with the latter group compared to other groups. Bush et al. (1955) reported that the rate of gain made by lambs fed 10.0 and 11.0% CP of DM diets was the same. Where as lambs fed 11.8% CP of DM diet made more rapid rate of gain regardless of the hay amount in the ration. Lambs fed the highest level of protein required slightly less total air-dried feed/unit of gain than lambs fed the diets containing other levels of crude protein.

2.4.2 Effect of dietary protein level on nutrients digestion and utilization:

Digestibilities of dry matter, organic matter, crude protein, nitrogen free extracts and energy were increased with increasing the protein level of the diet. This was confirmed by Graham (1964), Kay et al. (1968), Robinson and Forbes (1970), Ammerman et al. (1972), Greathouse et al. (1974), Kaiser et al. (1982) and Osman (1985). Graham (1964) found that the digestibilities of dry matter, crude protein, nitrogen free extracts and energy of the 20% CP diet were 1.2 times as great as those of 14% CP diet.

Ammerman et al. (1972) suggested that the increase in organic matter digestibility with increasing the level of protein in the diet could be attributed to the addition of more digestible feed to the least digestible basal diet. Robinson and Forbes (1970) and El-Hag and Mukhtar (1978) sug-
gested that apparent digestibility of crude protein was particularly dependant upon its proportion in the diet, since the metabolic fecal nitrogen fraction excreted was constant for equal dry matter intake and therefore a relatively reduced effect with diets rich in nitrogen than those poor in nitrogen.

Egan (1965a) found that duodenally infused nitrogen increased dry matter and energy digestibilities but not significantly. Hassan and Bryant (1966a) found that the digestibilities of organic matter, crude protein and energy were greater with concentrate diets than with those of high roughage diets of the same ME level and lower protein content. The dry matter digestibility was not affected.

Kaiser et al. (1982) reported that crude fibre digestibility increased with fishmeal supplementation. They suggested that this was probably an effect within the rumen, where the low protein diet resulted in a slower rate of release of specific amino acids which stimulated the cellulolytic activity. The same results were found by Osman (1983) who reported that crude fibre digestibility increased in a fairly uniform manner with increasing amount of protein content of the diet. On the contrary Graham (1964) found that crude fibre digestibility of the diet of the lower protein was 1.2 times as great as that of the higher protein diet. He concluded that the addition of high digestible maize
and peanut meal to hay lowered the digestibility of structural carbohydrate.

Greathouse et al. (1974) found that the total digestible nutrients value was least for the low protein diet. The same results were reported by Osman (1985) who found that the total digestible nutrients value was significantly improved by nitrogen supplementation. However, Elliott and Topps (1964) observed that the total digestible nutrients value of the diet decreased with increasing crude protein content of the diet fed to blackhead Persian sheep.

2.4.3 Effect of dietary protein level on nitrogen balance

Elliott and Topps (1963a) and Elliott and Topps (1964) found that there was a highly significant linear correlation between the percentage of total nitrogen in the diet and percentage of apparently digested nitrogen. Amoros et al. (1972), Fick et al. (1973) and Osman (1985) found that nitrogen intake increased as a result of increased nitrogen supplementation.

Daily urinary nitrogen losses by sheep were found to be highly increased with amount of nitrogen consumed (Elliott and Topps 1964). Fick et al. (1973) and Egan (1965b) found that nitrogen supplementation of diets increased fecal and urinary nitrogen excretion. In addition Egan (1965b) esti-
noted that the urinary and fecal nitrogen to be 7.11 g/d and 2.3 g/day respectively.

Robinson and Forbes (1970) and Greathouse et al. (1974) found that there were no significant differences between treatments in fecal nitrogen output, but there was a linear increase in urinary nitrogen output with increasing dietary nitrogen intake. Moreover, Kaiser et al. (1982) observed that the proportion of fecal nitrogen/nitrogen ingested was reduced with nitrogen supplementation whereas urinary nitrogen/nitrogen ingested proportion increased. Smith et al. (1980) noted that fecal and urinary nitrogen increased with increased dietary protein and the increase of the urinary nitrogen was greater than that of the fecal nitrogen.

Egan (1965b), Ammerman et al. (1972) and Holzer et al. (1986) reported that nitrogen retained (percentage of nitrogen intake or as g/day) increased considerably with nitrogen supplementation. Moreover, Hansen and Bryans (1986a) found that fishmeal supplementation almost doubled nitrogen retention in absolute terms and in relation to the intake of digestible organic matter. Robinson and Forbes (1970) noted that increased nitrogen retention followed a curvilinear relationship with dietary nitrogen consumption. Pick et al. (1973) reported that such an increase continued linearly until the level of 8% crude protein supplementation and was curvilinear at higher levels of supplementation. Moreover, Greathouse et al. (1974) observed that the
increase in nitrogen retention due to protein supplementation was not significant. However, they indicated that steers receiving higher protein diets tended to retain a higher proportion of the nitrogen consumed. Similarly Kaiser et al. (1982) suggested that protein supplementation increased nitrogen retention (g/day). However, nitrogen retained/kg liveweight and nitrogen retained as % of nitrogen ingested were unaffected by protein supplementation.

2.5 Joint effect of dietary energy and protein levels on animal performance and nutrients utilisation:

2.5.1 Joint effect of dietary energy and protein levels on animal performance:

Ammerman et al. (1972) reported that the supplementation of nitrogen sources (biuret, urea or natural protein) to hay basal diets increased voluntary intake of hay whereas supplementation of energy source resulted in hay consumption lower than that of sheep fed hay alone. They attributed the increase in voluntary intake of low quality roughages observed with nitrogen supplementation to the stimulatory effect of nitrogen on the cellulolytic microflora of the rumen with a resultant increase in the rate and degree of roughage digestibility and the rate of passage of residues through the gastrointestinal tract. The decrease in hay consumption with energy supplementation was a result of the substitution of the less digestible hay with the more readily digestible feed. Ahmed et al. (1979) used combinations of high and low
energy levels and high and low protein levels to determine the performance of Sudan desert sheep (NELP, 12.21 MJ ME/kg DM and 215 g CP/kg DM; HELP, 12.83 MJ ME/kg DM and 127 g CP/kg DM; LNH, 10.09 MJ ME/kg DM and 236 g CP/kg DM; and LELP, 11.12 MJ ME/kg DM and 142 g CP/kg DM) they observed no significant differences in the rate of body weight gain. However, the group receiving the high energy diet gained weight at a relatively higher rate than the other groups. El-Hag and Makhtar (1978) fed Sudan desert sheep 4 rations of different roughage to concentrate ratios. The protein percentage of the diets increased from 1.7 to 17.4% CP of DM with the increase of concentrate portion from 0 to 75% of the ration. Crude fibre content showed an opposite trend. The highest average daily weight gain was attained by the group fed the highest amount of concentrate and the least amount of roughage. The average daily feed consumption and feed conversion ratio were greater in sheep fed the rations containing concentrate than those fed the ration consisting of roughage alone. However, the differences in feed consumption were not significant among sheep fed concentrate rations. The feed conversion ratio was improved with decreasing the roughage portion in the ration. The superiority of concentrate rations over that of roughage alone was suggested to be due to their higher content of protein and easily fermentable carbohydrates.

Six mixed rations with concentrate to roughage ratios ranging between 0 : 100 were employed by Flaxter and Weinman
(1961) to feed 3 sheep and 3 steers at 2 different feeding levels. The lower feeding level provided an amount of energy lower than that required by the animal for maintenance while the higher feeding level provided an amount of energy twice what was provided by the lower level of feeding. The protein content ranged from 8.5% CP on the 100% roughage diet to 9.9% CP of DM on the 100% concentrate diet. The crude fibre content of the rations ranged from 33.8% to 2.2% respectively. They found that ME/100 Kcal gross energy intake increased linearly with increasing percentage of concentrate in the diet and it was not affected by the level of feeding with high concentrate diets; whereas the ME/100 Kcal gross energy intake was depressed at the high level of intake with high roughage diets. They attributed the difference to the increased energy losses and the increased urinary energy losses when animals are fed the high roughage diet.

Egan (1963 a) and Kaiser et al. (1982) reported that supplementation of protein significantly increased the intake of digestible energy. Robinson and Forbes (1970) suggested that the significant reduction in rate of body weight gain observed with rations containing low protein levels could be in part, due to reduced digestible energy intake.

Osman (1985) found that supplementing low energy low protein diet with molasses improved feed consumption but had no effect on rate of weight gain, whereas addition of nitrogen increased feed consumption as well as rate of weight gain. He
also observed that further supplementation of protein beyond the 11.4% CP level had no significant effect. In addition, he suggested that the superiority of the traditional ration used in the Sudan on the rate of weight gain and the feed conversion ratio was due to its higher energy density and protein content (81.5 TDN and 18.32% CP).

Elgindi et al. (1971 b) fed lambs 4 diets of different energy and protein levels. They found that the daily weight gain of lambs fed NEHP ration was higher than that of lambs fed HELP ration, whereas those fed LELP ration gained body weight faster than those fed LEHP ration. The efficiency of feed utilization was highest with LELP ration. The utilization of digestible protein/kg N\(^0.734\) was more efficient with lambs fed the NEHP than lambs fed LEHP. This indicated the importance of energy for saving digestible protein required from being utilized as energy source. Similar results were reported by Elliott and Topps (1963 a), Elliott and Topps (1963 b), Nuse et al (1970) and Mustafa (1980). Elliott and Topps (1963 a) studied the nitrogen balance of steers of two African cattle breeds given diets adequate in energy and low in protein. They observed that feed intake increased as the protein content of the diet was increased and there was a close relationship between the total nitrogen consumed and that retained in the body. They also observed that nitrogen retention was markedly increased when the diet contained adequate amount of available readily fermentable carbohydrate.
Accordingly they suggested that the protein sparing effect of energy, as was the case with monogastric species. Rume et al. (1970) reported that if the intake of energy is adequate to meet the maintenance requirements of the animal, the ruminal microflora population has the capacity to satisfy the animal requirements for protein. However, Egan (1976) reported that when voluntary intake of energy support bare survival, provision of a protein supplement instead of an energy supplement at the same level of digestible energy could increase intake and digestibility as well as decrease the rate of erosion of protein stores to provide glucogenic precursors. Mustafa (1980) fed Sudan desert sheep 3 different diets. Diet I was composed of durra and cotton seed cake in a ratio that provide the optimum energy and protein levels for sheep fattening as described by ARC (1963). Diet II was composed of humara supplemented with cotton seed cake to provide only the optimum protein level. Diet III composed of humara alone and was deficient in both energy and protein. He found that lambs fed on diet II made a slight gain and those fed on diet III lost weight, whereas the control group (Diet 2) gained more quickly. He also found that the protein percentage in the muscles of lambs fed diets II and III was lower than that of the control. This indicated that the former groups experienced protein depletion and shortage of energy. Lofgreen et al. (1951) fed calves with 4 ration groups HEP, HELP, LEP and LELP where LE and LP levels were recommended allowance of TDN and DCP of Morrison feeding standards where as
HR level was 115% of the LE level and the HF level was 160% of the LP level. They suggested that the rate of gain would be limited by the energy intake when the protein supply was sufficient to meet the needs of tissue synthesis. They further indicated that any excess protein would be used as an energy source. They concluded that supplementation of non-nitrogenous TN when protein is sufficient would stimulate faster rates of body weight gain and increase efficiency of protein utilization.

Pick et al. (1973) fed sheep on low quality roughages and supplemented them with energy and protein sources. They found that the level of dietary protein did not decrease feed intake until it fell below 7.0% CP of DM and that feed intake increased with increasing dietary energy level to a point above which any increase in dietary energy level decreased feed consumption. This decrease in feed consumption as a result of the highest energy level feeding was found to be greater without supplemental nitrogen. Shrestha et al. (1972) fed sheep barley straw (a low quality roughage) supplemented with groundnut meal and different amounts of calcium. They found that the supplementation of barley straw improved the intake of digestible energy and resulted in better rates of body weight gain and feed conversion. Andrews and Orskov (1970) fed weaned lambs diets containing different levels of protein at two feeding levels. They found that growth rate responded linearly to increased fed-
ing level and curvilinearly to increased dietary protein concentration. The dry matter intake decreased as the dietary protein concentration increased and this appeared more marked as the feeding level increased.

Holser et al. (1986) examined 2 levels of ME, (9.6 and 11.3 MJ ME/kg DM) in fattening of male cattle. Each of the diets contained 4 levels of protein. The control group diet had 90 g CP/kg DM and the other three diets had 140 g CP/kg DM, but different in the protein source. They found that the weight gain of cattle fed high ME concentration diet was 1.13 of that fed low ME concentration diet. This difference indicated that energy concentration limited rate of gain irrespective of protein supplementation. However, supplementation of low energy diet with protein from any source resulted in an increased rate of liveweight gain and reduction of the conversion ratio of ME into liveweight gain.

Jones and Hogue (1960), Elliott et al. (1966) and Smith et al. (1980) found that there was a significant energy X protein interaction effect on ruminant performance. However, Prior et al. (1977) found no significant energy X protein interaction effect on cattle performance. Jones and Hogue (1960) examined 4 rations (2 levels of protein X 2 levels of energy) on lamb performance. They found that lambs fed the high protein diets gained more than those fed the low protein diets and that the differences in liveweight gain due to dif-
ference in energy level failed to reach statistical significance. However, they observed a significant energy X protein interaction in liveweight gain and feed utilization efficiency. They noticed that increasing energy level of the high protein diet improved performance and that increasing energy with the low protein diet reduced performance of the lambs. The NLHP group gained faster than the others, but LSHP group was the most efficient. The HELP group gained slower and were the least efficient. The LSHP group gave the highest consumption of estimated net energy, while the HELP group consumed the least food.

Elliot et al. (1964) fed two African cattle breeds on rations of 2x2 energy and protein levels combinations. They found that most of the diets were readily consumed but some animals refused small amount of the diets low in digestible crude protein and high in digestible energy. The responses of daily weight gain to increased levels of DCP and energy were not independent and the interaction between them was highly significant. The daily weight gain increase with increasing DCP level was significantly reduced with low level of energy. Smith et al. (1980) conducted many experiments on barley straw and oat hulls as feed for yearling cattle. In one of the experiments they found that additional protein improved daily liveweight gain. Intake of digestible organic matter increased with increasing straw in the diet from 13% to 55% but was not affected by the dietary protein level. In another
experiment they found that daily liveweight gain increased by energy and protein supplementation. The interaction between protein and energy supplements was significant. In a third experiment they observed that daily live weight gain increased with higher energy level only. Prior et al. (1977) observed no significant protein x energy interaction when two breeds of cattle were fed rations containing two levels of energy and 3 levels of crude protein in a factorial design. They reported that the quantity of feed dry matter and feed crude protein consumed/kg liveweight decreased as the rations energy density increased. They also reported that total ME required to produce kg of liveweight gain was not influenced by ration energy level or cattle breed. The average daily gain and feed utilization efficiency reported were higher for medium and high protein ration fed animals than for those fed the low protein level ration.

2.5.2 Joint effect of dietary energy and protein levels on nutrients digestion and utilization:

Smith et al. (1980) observed that the digestibilities of dry matter and organic matter increased with increasing energy density of the diet when concentrate to roughage ratio increased. They also observed that protein supplementation of low roughage diets slightly improved the digestibilities of dry matter, organic matter and crude protein and that the improvement was more marked when high roughage diets were supplemented with protein. Ether extract digestibility was
Increased by protein supplementation of diets containing different concentrate to roughage ratios. However, it tended to decrease with increasing straw level in the diet. Fick et al. (1973) examined the effect of dietary protein and energy levels on the digestibility of nutrients. They reported that low protein level reduced organic matter and protein digestion. High energy level depressed crude fibre digestion but had no effect on organic matter or protein digestion. Holzer et al. (1986) found that dry matter digestibility increased with increasing dietary protein level but the effect was only significant when fish meal was used to supplement low metabolizable energy containing diet. Organic matter digestibility increased significantly with protein supplementation irrespective of the level of ME in the diet. The increase was not observed when the source of protein used was nonprotein nitrogen. Crude protein and nitrogen-free extracts digestibilities increased significantly with nitrogen supplementation in the two levels of metabolizable energy.

Blaxter and Wainman (1964), Forbes and Robinson (1969) and Hassan and Bryant (1986 b) supplemented diets with protein sources. The diets were offered to animals at different levels of intake to control the level of digestible energy intakes. Blaxter and Wainman (1964) found that energy digestibility increased significantly with increasing maize percentage in the diet, however, the higher level of feeding resulted in a depressed energy digestibility coefficient.
They also found that protein digestibility increased with increasing maize percentage in the diet. The increase of protein digestibility was more marked when the proportion of maize was increased above 60% of the diet. The effect of feeding level was not significant. Forbes and Robinson (1969) found that the apparent digestibilities of dry matter, organic matter and crude protein was higher on the low level of feeding when the protein content of the diet was 13.2%. However, dry matter and organic matter digestibility were significantly lower on the low level of feeding when the protein content of the diet was 17%. Hassan and Bryant (1986 b) found that dry matter, organic matter and gross energy digestibilities tended to decline with increasing level of feeding. Protein supplementation had no effect. The increase of nitrogen digestibility observed with reducing level of feeding was more marked with fish meal supplementation.

Total digestible nutrients (TDN) value improved with increasing dietary energy density and dietary protein concentration as reported by El-Ham and Hanad (1983) and El-Ham and Mukhtar (1978). They reported the improvement of TDN value with concentrate containing rations than with roughage alone ration that of lower energy and protein content.

2.5.3 Joint effect of dietary energy and protein levels on nitrogen balance:

Hassan and Bryant (1986 b) reported that nitrogen intake
significantly increased with protein supplementation as well as with increasing level of feeding. Smith et al. (1980) found that fecal nitrogen increased significantly with the reduction of dietary energy density as the straw level in the diet increased. They also observed that the urinary nitrogen showed the reverse pattern with increasing of the straw level in the diet and a significant increase with protein supplementation. The same results were reported by Hassan and Bryant (1986 a). Hassan and Bryant (1986 b) reported that the level of feeding and protein supplementation interaction were significant for urinary nitrogen output only. They found that daily urinary nitrogen increased with fishmeal supplementation. They observed that there was a positive relationship between urinary nitrogen excretion and feeding level of an unsupplemented diet and that a negative relationship was observed when the diet was supplemented with fishmeal.

The proportion of nitrogen retained increased significantly by increased dietary energy and protein levels (Smith et al. 1980). Moreover, El-Hag and Muhajar (1978) found that nitrogen balance improved with increased concentrate to roughage ratio in the diet for its higher content of protein and easily fermentable carbohydrates.

Hassan and Bryant (1986 b) found that the proportion of nitrogen retained (g/day) increased with increasing level of feeding and supplementation with fishmeal. The proportion of
nitrogen retained as proportion of total nitrogen intake also increased with the level of feeding. They found that the joint effect of protein and energy levels on nitrogen retention was significant when the latter was expressed as proportion of digested nitrogen. Similar results were obtained by Mitchell et al. (1940), Lofgreen et al. (1951), Poetenot et al. (1952), Elliott and Topps (1963 a) Elliott and Topps (1963 b) and Elgendi et al. (1971 a). They concluded that addition of protein supplements would not have an effect unless the energy was at an optimum level to satisfy the maintenance requirements of the animal. With inadequate energy levels, addition of protein would have no effect on nitrogen retention due to the lack of the protein sparing action exerted by energy rich diets.
1. Material and Methods

3.1 Feed and Feeding Trial:

Four experimental diets were formulated (Table 1) using Pearson's square method as was described by Church et al. (1974). The diets were formulated to contain combinations of low and high energy and protein levels. Nutrient composition of the diets is shown in Table 2. Accordingly the high energy and high protein diet, the high energy and low protein diet, the low energy and high protein diet and the low energy and low protein diet were designated as HEP, HELP, LEP, and LEP diets respectively. Diets ingredients were ground separately using a machine of 8mm. screen and then mechanically mixed.

8 Sudan desert male lambs were bought from Abu Zeid Market, north Omdurman. They were 6-9 months old and their body weight averaged 29.6 ± 0.3 kg. the lambs were sprayed with Gravetox, drenched with the anthelmintic phenothiazine and then ear tagged for identification. The lambs were randomly assigned to 4 groups each consisting of two lambs. They were kept in individual clean pens and each of the groups was offered one of the experimental diets described earlier.

The experimental design employed was a complete randomized block design. The experimental diets were offered to the lambs gradually. The lambs were offered 0.5 kg/day for the first two days. The amount of feed was increased gradually to ad libitum in a period of 14 days which represented an adaptation period.
<table>
<thead>
<tr>
<th>Ingredient</th>
<th>HPFP</th>
<th>HELP</th>
<th>LEFP</th>
<th>LELP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sesame cake</td>
<td>28.33</td>
<td>-</td>
<td>25.10</td>
<td>-</td>
</tr>
<tr>
<td>Sorghum grains</td>
<td>80.67</td>
<td>90.00</td>
<td>-</td>
<td>10.00</td>
</tr>
<tr>
<td>Cotton seed cake</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>36.00</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>-</td>
<td>-</td>
<td>34.00</td>
<td>-</td>
</tr>
<tr>
<td>Groundnut hulls</td>
<td>-</td>
<td>9.00</td>
<td>39.90</td>
<td>53.00</td>
</tr>
<tr>
<td>Salt</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Table 1. Ingredient Composition of the Experimental Diets ({} fed basis)
Table 2. Chemical Composition of the Experimental Diets (DM)

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Experimental Diets</th>
<th>SE ±</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HEMP</td>
<td>HREL</td>
</tr>
<tr>
<td>Dry Matter</td>
<td>94.1</td>
<td>93.6</td>
</tr>
<tr>
<td>Crude protein</td>
<td>20.3</td>
<td>14.1</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>4.9</td>
<td>8.4</td>
</tr>
<tr>
<td>Ether extract</td>
<td>5.0</td>
<td>4.7</td>
</tr>
<tr>
<td>Nitrogen free extract</td>
<td>64.4</td>
<td>67.9</td>
</tr>
<tr>
<td>Ash</td>
<td>5.4</td>
<td>4.5</td>
</tr>
<tr>
<td>Gross energy, MCal/kg</td>
<td>4.8</td>
<td>4.8</td>
</tr>
<tr>
<td>Digestible energy, MCal/kg</td>
<td>4.1</td>
<td>4.1</td>
</tr>
<tr>
<td>Digestible protein, % DMI</td>
<td>16.9</td>
<td>9.8</td>
</tr>
</tbody>
</table>

SE ± = Standard error.
The adaptation period was followed by a 56 days experimental period, during which lambs were offered the feed 
ad libitum. The feed was offered once daily in the morning and drinking water was available at all times. Feed offered and 
refusals were recorded and daily feed consumption was calculated. Lambs were weekly weighed following an overnight fast. 
After weighing lambs were left for 2 hours free out of their 
stocks to exercise. During the exercise time pens were 
cleaned and sprayed with Gamcox. The average daily gain was 
determined by dividing the average weekly body gain by 7 and 
the feed conversion ratio was obtained by dividing the daily 
feed intake by the daily weight gain.

3.2 The Metabolism Trial:—

One lamb from each treatment group was lifted up into a 
digestion crate. Each lamb was fed its respective treatment 
but ad libitum for an adaptation period of 5 days followed by 
3 faecal and urine collection period of 5 days. Lambs were 
fitted with canvas bags for daily total faeces collection. 
Urine was collected in Winchester bottles into which few 
drops of Sulphuric Acid were placed to reduce Ammonia loss. 
The weight of faeces and the volume of urine were measured 
daily at 8.0 a.m. in the morning. The 10% by weight fecal 
sample and 10% of the daily urine volume were collected every 
morning. The daily fecal samples were oven dried (48 hours) 
and were latter analysed by proximate analysis (A.D.A.C.)
The daily urine samples were analysed for their nitrogen content using microkjeldahl method (A.O.A.C. 1980).

Oven dried feed and fecal samples were ground using a Christy noris mill machine with a 1 mm. screen. Dry matter, nitrogen, ether extract, crude fibre and ash contents of the feed and faeces were determined using A.O.A.C. (1980) methods. The gross energy of feed and faeces was determined using a Parr 6141 Plain Jacket oxygen bomb calorimeter (Parr trade mark). The digestible energy values were calculated from the gross energy of feed and faeces.

The data obtained from the feeding and metabolism trails were subjected to analysis of variance in a factorial 2x2 complete randomized design as described by Snedecor and Cochran (1967) for determination of statistical significance. Significant differences among treatment means were determined using Duncan's New Multiple range test as described by Steel and Torrie (1980).
4. Results

4.1 Feeding trial results:—

The effect of the levels of dietary energy and protein on the feed consumption, body weight gain, digestible energy intake, digestible protein intake and feed conversion of Sudan desert lambs kept under feedlot conditions is shown in Table 3. It indicates that lambs receiving the LEMP and LELP diets consumed similar amounts of feed and digestible energy which were significantly (p 0.05) higher than those consumed by lambs on the OEMP and OELP diets. Lambs receiving the LELP and OELP diets consumed similar amounts of digestible protein which was significantly (p 0.05) less than that consumed by those on the OEMP diet and higher (p 0.05) than that of those on the OEMP diet.

The results in Table 3 also indicate that the dietary level of energy and protein had no effect on the rate of body weight gain.

The level of dietary energy and protein had no significant (p 0.05) effect on feed utilization. However lambs fed the OEMP, OELP utilized feed better (p 0.05) than lambs fed the LEMP and LELP diets.
4.2 Metabolism trial results:

4.2.1 Digestibility coefficients and the total digestible nutrients value results:

The effect of dietary energy and protein levels on digestibilities of dry matter (DM), organic matter (OM), crude protein (CP), crude fibre (CF), ether extract (EE), nitrogen free extract (NFE), energy and total digestible nutrients value (TDN) is shown in Table 4. It indicates that the level of dietary energy and protein had no effect on DM and OM digestibilities. The level of dietary energy and protein had a significant (p<0.05) effect on CP, CF, EE, NFE and energy digestibilities as well as TDN value. CP digestibility of the LMKP was similar to those of LEMP and NEMP diets. The CP digestibility of the NEMP diet was significantly (p<0.05) higher than that of NEMP diet, whereas that of HELP diet was significantly (p<0.05) less than those of the others. CP and EE digestibilities were similar for the LEMP and LELP diets which were significantly (p<0.05) higher than those of the NEMP and HELP diets. Energy digestibilities were similar for the NEMP and HELP diets that were significantly (p<0.05) higher than those of the LEMP and LELP diets. For the NFE digestibility and TDN value, the HELP, LEMP and LELP diets were similar and were significantly (p<0.05) less than the NEMP diet.
Table 4. Effect of levels of dietary energy and protein on nutrients digestion by Sudan desert lambs.

<table>
<thead>
<tr>
<th>Digestibility Coefficient (DM)</th>
<th>Experimental Diets</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HERF</td>
<td>HELD</td>
</tr>
<tr>
<td>Dry Matter</td>
<td>81.8 b</td>
<td>76.2 c</td>
</tr>
<tr>
<td>Organic matter</td>
<td>86.6 b</td>
<td>78.8 c</td>
</tr>
<tr>
<td>Crude protein</td>
<td>83.4 b</td>
<td>71.0 c</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>49.3 b</td>
<td>34.5 b</td>
</tr>
<tr>
<td>Ether extract</td>
<td>80.4 b</td>
<td>78.0 b</td>
</tr>
<tr>
<td>ENE</td>
<td>90.4 a</td>
<td>86.0 b</td>
</tr>
<tr>
<td>Energy</td>
<td>86.4 a</td>
<td>86.4 a</td>
</tr>
<tr>
<td>DGA, N×10^2/kg</td>
<td>87.7 a</td>
<td>81.2 b</td>
</tr>
</tbody>
</table>

2, 3, a, b, Means in the same row with different superscripts are significantly different (p<0.05)

SE = Standard error.
4.2.2 Nitrogen balance results:

The joint effect of dietary energy and protein levels on nitrogen intake (g/day) as well as faecal, urinary, and retained nitrogen in g/day and as % of nitrogen intake was presented in Table 5. It shows that nitrogen intake (g/day) and urinary nitrogen excretion (g/day and as % of nitrogen intake) were similar for LEMP and LELP diets which were significantly (p<0.05) higher than those of MEMP and HELP diets. For faecal nitrogen (g/day), the LEMP diet group excreted significantly (p<0.05) higher amount than LEMP diet and lower (p<0.05) than HELP and LELP diets which were similar. The faecal nitrogen (as % of nitrogen intake) for LELP diet was similar to those for LEMP and MEMP diets, whereas that for TNP diet was significantly (p<0.05) higher than that for LEMP diet. The faecal nitrogen output (as % of nitrogen intake) for the HELP diet was significantly (p<0.05) higher than that for the other treatments. Results in Table 5 also indicate that levels of dietary energy and protein had no effect on nitrogen retained (g/day). However, it is clear that lambs on LEMP and LELP diets tended to retain more nitrogen (g/day) than those on MEMP and HELP diets. For nitrogen retention (as % of nitrogen intake) the HELP and LEMP were similar to LELP diets. They were also similar to TNP diet that was significantly (p<0.05) higher than LELP diet.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Experimental Diet</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HEP</td>
<td>RLP</td>
</tr>
<tr>
<td>Nitrogen intake, g/day</td>
<td>14.68&lt;sub&gt;b&lt;/sub&gt;</td>
<td>17.70&lt;sub&gt;b&lt;/sub&gt;</td>
</tr>
<tr>
<td>Fecal nitrogen, g/day</td>
<td>2.36&lt;sub&gt;c&lt;/sub&gt;</td>
<td>5.13&lt;sub&gt;a&lt;/sub&gt;</td>
</tr>
<tr>
<td>Fecal nitrogen, (% of nitrogen intake)</td>
<td>16.2&lt;sub&gt;b&lt;/sub&gt;</td>
<td>29.0&lt;sub&gt;a&lt;/sub&gt;</td>
</tr>
<tr>
<td>Urinary nitrogen, g/day</td>
<td>5.92&lt;sub&gt;b&lt;/sub&gt;</td>
<td>7.21&lt;sub&gt;b&lt;/sub&gt;</td>
</tr>
<tr>
<td>Urinary nitrogen, (% of nitrogen intake)</td>
<td>40.6&lt;sub&gt;b&lt;/sub&gt;</td>
<td>41.0&lt;sub&gt;c&lt;/sub&gt;</td>
</tr>
<tr>
<td>Nitrogen retained, g/day</td>
<td>6.30</td>
<td>5.36</td>
</tr>
<tr>
<td>Nitrogen retained, (% of nitrogen intake)</td>
<td>43.2&lt;sub&gt;a&lt;/sub&gt;</td>
<td>33.3&lt;sub&gt;b&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

<sub>a,b,c</sub>, Means in the same row with different superscripts are significantly different (p<0.05)

SE = Standard error.
5. Discussion

..1 Feeding Trial: -

The high feed consumption of the lambs on the low energy diets is in agreement with Cullough (1974), Prior et al. (1977), Andrews (1982) and Mohamed (1986). They suggested that ruminants adjusted their voluntary feed consumption to their physiological demand for energy unless the rumen capacity restricts further intake of feed. They also suggested that ruminants eat to maintain a constant digestible energy intake. In the present study lambs on the high energy diet consumed smaller amount of feed to satisfy their digestible energy intake, whereas, the lambs on the lower energy diets consumed greater amount of feed to reach the same level of satisfaction of digestible energy intake.

Within each level of energy groups the different levels of dietary protein had no effect on feed consumption. This observation is in agreement with the results of Fick et al. (1973) and Elliott and Topps (1983 c) who suggested that increasing dietary protein level beyond 8% had no effect on feed consumption. Similar result were reported by Weston (1971), when he increased the dietary protein level beyond 15.8%; and Kay et al. (1969) when they increased the dietary protein level beyond 14% and also Mansour (1987) when he increased it beyond 11.4%. However all of them observed the tendency of increased feed consumption with increased dietary crude protein level.
Egan (1965 a) and Elliott and Toppes (1963 c) suggested that increasing nitrogen absorption from the duodenum resulted in a chemostatic control effect governing the intake of roughages of low nitrogen content. This could be behind the increased animal appetite and rate of feed digestion. They also observed that such effect was reduced when the level of nitrogen in the diet offered exceeded the concentration required for maximum production. This may explain the non significant effect of protein level on feed consumption in the present study.

Lambs on the low energy diets consumed significantly (P < 0.05) higher digestible energy than that on the higher energy diet (5.2 Mcal/day Vs 4.2 Mcal/day). This is different from results of Kironka et al. (1984) and Mohamed (1986) who observed that digestible energy consumption by animals is a constant and was not affected by the level of feeding or feed energy density. This may in part be due to the high % of crude fibre in the low energy diets, that decreases the % of net available energy for production and increases the demand of digestible energy as reported by Graham (1964) and Nixter and Wainman (1964). They suggested this to happen as a result of increased energy loss, in the form of methane production in the rumen and more work done in chewing, that were subtracted from the digestible energy. The increased demand of digestible energy is perhaps behind the increased digestible
energy intake by lambs on the low energy diets. Moreover, Blissard et al. (1961) reported that the digestible energy consumed, Mcal/day/kg \( w^{0.734} \), increased with the increasing voluntary feed intake, g/day/kg \( w^{0.734} \).

The non significant effect of dietary protein level on the digestible energy intake is in agreement with Kaiser et al. (1982) when he increased the protein level beyond 8.4 g/kg DM in the diet. Similar results were obtained by Wistun (1971) and Shrestha et al. (1972).

Lambs on the low energy diets consumed higher digestible crude protein. This could be due to their higher consumption of dry matter as reported by Elliott and Torps (1961 b) and Mohamed (1986) who observed that the lower feed consumption of higher energy diets restricted the intake of nutrients other than energy.

Lambs on the high protein diets consumed higher digestible crude protein than their counterparts on the low protein diets but the same dietary energy level. This is in agreement with Serif and Manke (1970) who found that the digestible protein intake increased from 97.2 to 132.6, 133.6 and 141.3 g/kg when the dietary protein level was increased from 8 to 138, 128 and 148 g/kg DM respectively. The present results of the digestible crude protein intake resemble that
of Ragan (1976) and Elliott and Topp (1974) who noted that when the energy intake was optimum to support bare survival provision of protein supplementation instead of an energy supplement will increase intake and digestibility of forage available.

The effect of energy level on the body weight gain of lambs was not significant, however, the lower energy diets groups tended to gain at a slightly faster rate. This is in agreement with Andrews et. al. (1959) and Ahmed et. al. (1979). The superiority of the low energy diet groups on weight gain rate could be due to the lower feed intake of the high energy diet groups, that restricted the intake of nutrients essential for body weight growth other than energy and mainly protein (Mohamed 1985; Buxton et. al. 1961 and Mulkar and Osman 1960.)

The non significant effect of the dietary protein level on the body weight gain of lambs is similar to that found by Kay et. al. (1968), Sarif and Menke (1970), Kaiser et. al. (1982), Osman (1985) and Mansour (1987). They found that the increase of protein level beyond that suggested by the NRC (1975), to be optimum for maximum production (11.0% CP), has no significant effect on body weight gain. They also noted the tendency of the high protein treatment groups to gain at a slightly faster rate. This was observed with the low energy group. They suggested this to be due to the increased intake of diges-
tible nutrients. Moreover, Vipand et al. (1982) noted that the superiority of the high protein diets could be due to the increased amount of protein escaping degradation in the rumen to be digested properly in the abomasum. There was no significant energy X protein interaction effect on body weight gain. This is in agreement with Prior et al. (1971), Andrews and Ovezov (1976) and Hassan and Bryant (1986 b). This could be due to the fact that the levels of energy and protein used in the present study are higher than that suggested to be optimum.

The feed conversion ratio was not affected significantly by energy level, however, the high energy level slightly improved the feed conversion ratio of feed. This is in agreement with Andrews (1982) and Mohamed (1986). The slightly poorer feed conversion ratio of lambs fed the low energy diets also agreed with that of El-Singy and Mokhtar (1978) and Garnsworthy (1984) who suggested this to be due to the higher dietary fibre content that reduced the net energy available for production.

The non significant improvement of the feed conversion ratio as a result of dietary protein level increase in the present study is similar to that obtained by Greathouse et al.
higher total feed intake and consequently the nitrogen intake of the low energy diet groups.

The higher crude protein digestibility of the high protein diet groups was also found by Elmag and Mukhtar (1978), Kaiser et al. (1982), Holzer et al. (1986) and Hasnan and Bryant (1986 a) noted that the crude protein digestibility was particularly dependant upon its proportion in the diet since the metabolic fecal nitrogen fraction excreted was constant for equal dry matter intake and so could have a relatively lesser effect on the crude protein digestibility of the rich nitrogen diets. This may explain the significant effect of protein level within the high energy diet groups. It will also explain the non significant effect of protein level within the low energy diets that had feed intake higher enough to lessen the effect of dietary protein level. For the non significant differences between the low energy low protein diet group and the high energy high protein diet group on crude protein digestibility; the effect of the higher feed intake of the former group lessened the effect of the higher % of dietary crude protein of the latter group.

The low energy diet groups had significantly (p<0.05) higher crude fibre digestibility. This is the same as Chap-pell and Fontenot (1968) Osman (1986), Pick et al. (1973) Mustin and Wing (1966) and Stone and Fontenot (1965). They noted that the decrease of crude fibre digestibility with
increasing of available energy concentration in the diet could be due to the preference of the rumen microorganisms to the easily fermentable carbohydrates rather than the crude fibre. They suggested this is to be behind the higher rate of fermentation and consequently the rate of outflow of the high energy diets, and this was inversely related to the crude fibre digestibility.

Protein level had no significant effect on crude fibre digestibility. This may be due to the higher levels of protein used. The same observation was noted by Holzer et al. (1986).

The low energy diet groups had significantly (p<0.05) higher ether extract digestibility. This is different from that of Stone and Fontenot (1968) who reported that the level of energy had no effect on ether extract digestibility. This significant high ether extract digestibility of the low energy group in the present study may be due to their higher feed intake (1767 and 1670 g/day Vs 1020 and 1035 g/day for the low energy and high energy diet groups respectively). The difference in feed intake was high enough to overcome the difference in the % of dietary ether extract (2.4 and 2.2% EE Vs 5.00 and 4.73% EE for the low energy and high energy groups respectively). Ether extract digestibility was not affected by the level of dietary protein. This is in agreement with ElMay and Mukhtar (1978) who noted that the ether extract digestibility varied with no dependency upon the
changes of concentrate to roughage ratios in the diet fed to Sudan desert lambs.

The higher nitrogen free extract digestibility of the high energy diet groups was also observed by Osman (1985), El-Hag and Mukhtar (1978) and Stone and Fontenot (1965). Within the low energy diet groups the protein level had no effect on nitrogen free extracts digestibility and this may be due to their higher feed intake that increased digestibilities of feed nutrients. Within the high energy diet groups the high protein treatment group had significantly (p<0.05) higher nitrogen free extracts digestibility. This significant difference could be due to the differences in the crude protein, crude fibre and other extract digestibilities that were higher enough to make the nitrogen free extract digestibility differed significantly. In addition Graham (1964), Greathouse et al. (1974) and Holzer et al. (1986) reported the nitrogen free extract digestibility to increase significantly with dietary protein level increasing. These observations was clearly observed with the results of the high energy diet groups.

The energy digestibility was higher for the high energy diet groups and this is in agreement with Chappell and Fontenot (1969), Stone and Fontenot (1965), Andrews et al. (1969) and Hassan and Bryant (1986 b). Protein level had no effect on energy digestibility and this is similar to that found by
Hassan and Bryant (1986 b) and Kaiser et. al. (1982). There was no energy x protein interaction effect on energy digestibility as reported by Hassan and Bryant (1986 b).

The high energy diet groups had higher value of total digestible nutrients (TDN) than that of the low energy diet groups; however, the difference was not statistically significant (p<0.05). This resembles the findings of Stone and Fontenot (1965), Loggreen and otogaki (1969), Elmag and Makhtar (1975) and Osman (1985). The protein level had no significant effect on the TDN value with the low energy diet groups. This is similar to the findings of Greathouse et. al. (1974), who found the tendency of the high protein treatment group to have a higher TDN value. This assumption can be observed with the high energy diet groups but the difference was significant and this could be a joint effect of the lower intake and lower digestibilities of feed nutrients of the high energy low protein diet.

5.2.2 Nitrogen Balance:
Lambs on the low energy diets had significantly (p<0.05) higher nitrogen intake. This is a result of their higher feed intake as reported by Stone and Fontenot (1965) and Loggreen et. al. (1951). The protein level had no effect and this is similar to that observed by Piek et. al. (1973) who noted no effect on nitrogen intake when the dietary protein level was increased beyond 8%.
Lambs fed the low energy diet groups had higher fecal nitrogen output (g/day), however the difference was not significant between the low protein groups in the high and low energy levels. This is in agreement with Smith et al. (1980) and Smith and Broster (1977). They suggested this is to be due to the higher fibre content of the diets of the low energy groups that increased the metabolic fecal nitrogen excretion. In addition, Osman (1985) suggested the higher fecal nitrogen of the low energy diet groups to be due to their higher nitrogen intake.

The significantly higher amount of the fecal nitrogen extracted by the lambs fed low protein diets was also noted by Elliott and Toops (1963a), Elliott and Toops (1964) and Kaiser et al. (1982) who suggested this to be due to the increased digestibility of protein for the high protein diets.

The fecal nitrogen (as % of nitrogen intake) was higher for the high energy groups. The low protein treatment groups had the higher proportion of nitrogen excreted in faeces, however the difference was not significant within the low energy diet groups. These results are in agreement with that observed by Smith and Broster (1977), Kaiser et al. (1982) and Osman (1985). They attributed this to the higher metabolic fecal nitrogen relative to the lower nitrogen intake for the high energy groups compared to the low energy groups.
and for the low protein diet group compared to their counterparts on the high protein diet but the same dietary energy level.

The urinary nitrogen (g/day and as % of nitrogen intake) was significantly higher (p<0.05) for the low energy diet groups. This is similar to the finding of Singh and Mahadevan (1970), Osman (1985), Senth et al. (1980) and Chappell and Kettner (1968). They attributed this to the higher nitrogen intake of the low energy diet groups. The dietary protein level had no significant effect on the nitrogen excreted in urine in g/day or as % of nitrogen intake. Similar results were also found by Fick et al. (1973).

The dietary energy level had no significant effect on nitrogen retained (g/day) and this is similar to that found by Forbes and Robinson (1969), Fick et al. (1973), Singh and Mahadevan (1970), Osman (1985) and Greathouse et al. (1974). They noted that the increase in nitrogen intake that caused by the decreasing of dietary energy level had no significant effect on nitrogen retention since urinary nitrogen was also increased. This may also explain the non significant effect of dietary protein level on nitrogen retained in this study. The non significant increase of nitrogen retention of the high protein diet groups is similar to that observed by Holster et al. (1986), Ammerman et al. (1974), Kaiser et al. (1982), Robinson and Forbes (1970), and Fick et al. (1973).
Both dietary energy and protein levels had no significant effect on nitrogen retention as % of intake. This is in agreement with Osman (1985), Stone and Fontenot (1965) and Fick et al. (1973). The significant (p<0.05) lower proportion of nitrogen retained for the low energy low protein diet group could be due to the poor digestion and utilization of the dietary nitrogen that is manifested by the higher proportion of fecal and urinary nitrogen output. (Osman, 1985; Kaiser et al., 1982 and Fick et al. 1973). The non significant superiority of the high protein diet groups on the proportion of nitrogen retained was also observed by Holser et al. (1986).

There is no energy protein interaction effect on nitrogen retained in g/day or as % of nitrogen intake. This is in agreement with Smith et al. (1980). This observation may be due to the fact that both levels of energy used in the present study are high enough to assure proper protein utilization as reported by Elgindi et al. (1971 a), Egan (1976) and Elliott and Toppes (1964).
6.3 Conclusions:-

From this research it was concluded that:-

1. Supplementation of energy more than the level of 30 kcal DE/kg DM of feed has a reverse effect on feed consumption and weight gain.

2. Supplementation of protein beyond 14% CP in the diet has no significant effect on feed consumption and weight gain.

3. Increasing protein intake has no effect on nitrogen retention, since the urinary nitrogen output will be increases.
6. Summary

A feeding trial and a metabolism were conducted to study the effect of dietary energy and protein levels on performance and nutrient utilization by growing Sudan desert lambs. Eight Sudan desert lambs of 8-9 months old were assigned to 2 treatments of 2 animals each, for a feeding trial of 70 days, 14 days of which for adaption. A metabolism trial for the same rations used in the feeding trial was conducted. One animal for each ration for 10 days, 5 days of which for adaptation. The rations used were combinations of 2 levels of energy and protein. The levels of gross energy used were 4.6 and 4.4 Mcal/kg for the high and low levels respectively. The levels of protein used were 20% and 14% CP for the high and low levels respectively. Data of the feeding and metabolism trials were subjected to analysis of variance in a factorial ANOVA complete randomized design.

The results of the feeding trial indicated that both dietary energy and dietary protein levels had no significant effect on daily liveweight gain of lambs. The low energy diet groups had significantly higher feed consumption, digestible energy and digestible protein intakes. The level of dietary protein had no significant effect on feed consumption and digestible energy intake. The digestible crude protein intake was significantly higher for the high protein diet groups. The high energy and high protein levels improved the feed...
conversion ratio, however, the difference was not statistically significant.

The data of the metabolism trial showed that the levels of dietary energy and dietary protein had no significant effect on dry matter and organic matter digestibility coefficients. The low energy diet groups had significantly higher crude protein, crude fibre and ether extract digestibility coefficients and significantly lower energy digestibility coefficient. The high protein level produced significantly higher crude protein digestibility coefficient and higher total digestible nutrients percentage with the high energy level only.

Both dietary energy and dietary protein levels had no significant effect on the daily nitrogen retention (g/day). As a % of nitrogen intake, the low energy low protein diet group retained significantly less nitrogen than other groups.
7. References


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لا يمكنني قراءة النص العربي في الصورة.```
أظهرت نتائج تجربة التسمين عدم وجود أي رمز ممكن لمستويات الطاقة والبروتين على معد الطرق البياني للمعلومة. كانت النتائج التي أعطيت للأندسة ذات المستوى اللامائي من الناقة أعلى، وأكثر استحالة للذين لم يتواجدوا للطاقات المائية والبروتينات المتغيرة. لم يكن لهذين البروتينين في البداية أي تأثير على استغلال الطاقة والبروتين. وتناول النقاتة المائية، مما يتناسب البروتينات اليومية. كانت البروتينات الأخرى ذات مستوى البروتينات القليل أكثر تأثيرًا على مستوى النقاتة، وتفسير النجاح في النقاتة، ولكن النوع المرجع.

 Aristotle's stance on the necessity of a universal law. jego 45x1172 to 74x1183.