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# RELATIONSHIP BETWEEN THE DIETARY ENERGY AND THE NUTRIENTS UTILIZATION, BLOOD BIOCHEMICAL CHANGES AND FOLLICULAR DYNAMICS IN DROMEDARY SHE-CAMEL (*Camelus dromedarius*)

(With 9 Tables and 7 Figures)

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## العلاقة بين الطاقة في العلائق ومدي الاستفادة من المواد الغذائية والتغيرات البيوكيميائية في مصل الدم وديناميكية الحويصلات المبيضية في إناث الجمال وحيدة السنام

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فـــي هذه التجربة تم دراسة أثر تغذية إناث الجمال وحيدة السنام علي علائق ذات مستويات مخـــتلفة مـــن الطاقـــة علـــي كل من كمية الأكل المستهلك ومعاملات هضم المواد الغذائية والتغيرات البيوكيميائية في مصل الدم بالإضافة إلى ديناميكية الحويصلات المبيضية في إناث الجمـــال وحـــيدة السنام. أجريت التجربة علي عدد ثلاث من إناث الجمال عمرها ٥ سنوات ووزنهـــا من ٤٠٠ إلى ٥٠٠ كجم في ثلاث محاولات متتالية أعتبرت كل منها تجربة قائمة بذاتها استغرقت كل منها ٣٠ يوما, في المحاولة الأولى تمت تغذيتها علي عليقة منخفضة في الطاقة ٢٠% أقل من المقررة بينما في المحاولة الثانية فقد غذيت الإناث علي العليقة المقررة لهذا النوع من الحيوانات كعليقة مقارنة وأعتبرت عليقة ضابطة أما في المحاولة الثالثة غذيت الحـــيوانات علي عليقة مرتفعة في الطاقة ٢٠% وقد خلصت التجربة إلى أن معدل استهلاك المـــادة الجافـــة ومعاملات هضم المادة الجافة والعضوية والبروتين الخام والدهون والألياف والكالســـيوم والفوسفور كانت أعلي معنويا في إناث الجمال المغذاة علي العليقة المرتفعة في الطاقـــة مقارنـــة بالمجموعـــات الأخرى بينما العليقة منخفضة الطاقة أثرت سلبيا علي هذه المعـــدلات. عـــدم وجـــود أية فروق معنوية في تركيز كل من البروتين الكلي والالبيومين والجلوبيليـــن فـــي مصل الدم بين الجمال المغذاة علي كل من العليقة المقارنة والمرتفعة في الطاقـــة فـــي حيـــن ســـجلت الجمال المغذاة علي عليقة منخفضة في الطاقة أقل قيم في هذه التركـــيزات. كان تركيز الجلوكوز والجليسريدات الثلاثية والكوليستيرول الكلي والصوديوم والكلورين والبوتاسيوم والكالسيوم والفوسفور والماغنسيوم في مصل دم الجمال المغذاة علي علـــيقة مـــرتفعة فـــي الطاقـــة أعلي معنويا عنه في الجمال المغذاة علي العليقة المقارنة أو

المنخفضـــة فـــي الطاقة. كان تركيز هرمونات النمو أعلي في مصل دم الجمال المغذاة علي علـــيقة منخفضة في الطاقة مقارنة بالمجموعات الأخرى. كانت هناك زيادة معنوية في عدد الحويصلات متوسطة وكبيرة الحجم في إناث الجمال المغذاة علي العليقة المرتفعة في الطاقة أو العلـــيقة الضابطة مقارنة بالمجموعة المغذاة علي عليقة منخفضة في الطاقة. كذلك وجدت زيادة معنوية في حجم أكبر وثاني أكبر حويصلة مبيضية مع رفع مستوي الطاقة في العلائق مقارنـــة بالمستوي المنخفض في الطاقة. من هذه الدراسة نستنتج أن العلائق مرتفعة الطاقة تـــؤدي إلـــى تحســـن في حالة الحيوان من حيث زيادة معدل الاستفادة من العناصر الغذائية وزيادة ديناميكية الحويصلات المبيضية.

## SUMMARY

The effect of different dietary energy levels on the feed intake, nutrient digestibilities, blood biochemical changes and ovarian follicular dynamics of dromedary she-camel in Southern Egypt were tested by feeding three dietary levels of energy and keeping the protein levels fixed in a three trials, each of one month. Three healthy one-humped she-camels; 5 years old and about 500 kg weight; were fed as a group during each of the three trials. They were fed on 3 diets differed in energy levels; in the first and third trials, camels were fed on diets 20% lower and higher in the energy, while in the second trial, animals were fed on the comparable diet that supply the needs for energy (2.17 Mcal ME/kg) and considered as control. The results showed that, dry matter intake was significantly (P<0.05) high for camels fed on high energy diet compared to those fed on the low energy and comparable ones. The digestion coefficients of DM, OM, CP, EE & CF were significantly (P<0.05) higher in the camels fed the comparable and high-energy diets, while low energy diet negatively affected the nutrient digestibilities. The total serum protein, albumin and globulin values revealed no significant differences (P<0.05) among the animals fed on the comparable and high energy diets, while camels fed on the low energy diet recorded significantly (P<0.05) lower values. Glucose, triglycerides and total cholesterol concentrations of serum revealed higher significant (P<0.05) values in camels fed on high-energy diet than comparable and low energy diets. Serum concentrations of sodium, chlorine, potassium, calcium, phosphorus and magnesium were significantly (P<0.05) higher in the serum of camels fed on high-energy and comparable diets in comparison with that of low energy diet. Concentrations of growth hormone (GH) in blood are increased by low dietary energy. Number of large and medium sized follicles were increased significantly (P<0.01) during the trials in which the animals fed the comparable and high energy diets than the low energy diet. A significant (P<0.05) increase in the size of the largest follicle and second largest follicle was recorded during the trial of high energy diet compared with the other two trials. In conclusion, high-energy diet improved the condition of she-camels, which is reflected on the utilization of the nutrients and ovarian activity.

***Key words:*** *Energy, nutrient utilization, biochemical changes, follicular dynamics, camels*

## INTRODUCTION

Efficient utilization of nutrients depends on adequate supply of energy, which is of paramount importance in determining the productivity as deficiency of energy delays puberty and reduce fertility (Singh & Sengar, 1970). Deficiency of energy reduces rumen function and lower the efficiency of feed utilization, however, high dietary energy greatly increase calcium and phosphorus retention compared to diet low in energy (Rosero *et al.*, 1983). The onset of puberty and the age at first parturition could be affected by several factors including nutritional status, season of birth and breed or type of camel. In the dromedary camels, nutrition and adequate growth seem to be the most important factors affecting reproductive parameters in the young females (Tibary and Anouassi, 1999). In farm animals, undernutrition delays the onset of puberty and leads to impaired fertility in mature animals. Heat symptoms have been found to occur at later stages in underfed heifers than in heifers fed adequate diets (Moustgaard, 1972). There is a well established relationship between energy deficiency and fertility problems (Heinonen *et al.*, 1988; Villa-Godoy *et al.*, 1988 and Butler & Canfield, 1989). Definition of the estrus cycle in camelidae is very complicated and it is not surprising that, there are large discrepancies in the literature concerning its length. This is due to the fact that ovulation in these species is not spontaneous but rather induced by coitus. In the absence of ovulation, the ovarian activity is limited to a succession of regular follicular variations called follicular waves (Arthur *et al.*, 1996). Nutrition can affect ovulation rate by two possible pathways; the first is acting on the gonadotrophic axis, the second being direct action on the ovary (Landau *et al.*, 1996). The most effective therapy for reproductive performance is maximal appetite and maximal consumption of dietary calories (Beam, 1996). Energy is important for growth and the pubertal process and energy intake has been reported to be related to reproductive performance of cattle (Butler *et al.*, 1981; Flipot *et al.*, 1988). Prolonged restriction of dietary energy delays onset of puberty, disrupts cyclicity in sexually mature animals (Schillo, 1992). Lucy *et al.* ($1991_a$) reported that ovarian function and follicular size were affected by energy balance. The failure of ovarian follicles to reach mature size and ovulate (Kesler and Garverick, 1982) represent significant sources of reproductive inefficiency in cattle experiencing low energy diets (Bauman and Currie, 1980). In addition, poor responses to producers for synchronization of estrus (Stevenson *et al.*, 1987; Van Cleeff, 1991) may be associated with inconsistent growth and development of ovarian follicles caused by low energy diets. Ovarian inactivity may result from insufficient LH secretion associated with inadequate energy intake (Imakawa *et al.*, 1986; Lucy *et al.*, 1991b). Feeding diets higher in energy may stimulate ovarian function (Lucy *et al.*, 1991b) and increased energy balance was associated with the movement of follicles into larger size classes (Lucy *et al.*, 1991c). Studies on other species showed that ovarian activity is greatly affected by the levels of circulating minerals, proteins, cholesterol and glucose in the blood of animals (Osman *et al.*, 1970; Zintzen, 1972; Rowlands *et al.*, 1980; Dhoble & Gupta, 1981 and Shehata, 1983).

The present study was conducted to asses and compare the effect of diets having 20% less or more than the recommended energy levels on the nutrients utilization, blood biochemical changes and ovarian follicular dynamics of dromedary she-camel at Southern Egypt.

## MATERIALS and METHODS

**1- Animals**:

Three healthy female one-humped she-camels aged 5 years and weighed about 500 kg were used in this investigation. The animals were clinically healthy and the parasitological examination revealed no gastrointestinal infestation. The three animals forming one group, were fed during three trials, each of one month, on three isonitrogenous diets but differing in energy level.

**2- Housing and feeding:**

Three serial trials were carried out on the she-camels to determine the effect of the energy levels on nutrients utilization and blood biochemical changes in addition to its effects on the ovarian follicular dynamics. The animals were designated to receive diet with low energy level (1.75 Mcal/kg diet) for one month starting from the onset of the breeding season (the beginning of the breeding season was marked by the appearance of the first preovulatory follicle over 15 mm during ultrasonographic examination as well as first behavioral estrus).

In the second month, animals were kept on diets having the recommended level of energy, and this stage was considered as the comparable stage, while during the last month of the experiment, the animals fed diet of high energy level (2.61 Mcal/kg diet).

The comparable diet was formulated to satisfy the needs for energy and crude protein (control) followed the nutrient recommendations of Warda *et al.* (1989) for camels, contained about 2.17 Mcal ME/kg diet and 8.18% crude protein (on DM basis) as shown in Table (1 & 2), while the low and high energy diets were lower and higher by 20% than that of comparable one.

Camels were housed individually under the prevalent environmental conditions in separate pens where feed intake was recorded and fecal matter collected throughout each trial (30 days), 24 days as a preliminary period followed by 6 days as a collecting one. The diets were given twice daily at 9.00 a.m and 5.00 p.m and any residues were collected and weighed throughout the experimental trials and all animals had free access to clean water. For estimating digestibility, chromic oxide was mixed with the diet ingredients at a rate of 0.5% as an indicator.

**3- Samples:**

**3.1-Feeds and fecal matter:**

Feed ingredients used in the experimental diets were sampled, dried, ground and analyzed for different nutrients. Representative samples of fecal matter were taken over 6 days at the end of each trial, then dried for 24 hours at 60°C, pooled together, mixed ground and stored till analysis.

**3.2-Blood:**

Blood samples were taken before the morning meal from the jugular vein in a dry, clean and sterile centrifuge tubes. The samples were allowed to be clotted at room temperature. The clotted blood were centrifuged at 3000 rpm for 20 minutes. A clear, non haemolysed sera were separated by pasteur-pippette and transferred into a clean, dry and sterile stoppered glass vials till beforming the biochemical analysis.

**4- Analysis:**

Feed ingredients and fecal samples were analyzed according to AOAC (1990).

**5-Digestibility estimation:**

From the analysis of food, and fecal matter and tracing the concentration of chromic oxide (Williams *et al.*, 1962), digestibility could be calculated according to the equations:

$$\text{Digestibility of DM} = \frac{\text{g indicator / kg feces} - \text{g indicator / kg food}}{\text{g indicator / kg feces}} \times 100$$

(McDonald *et al.*, 1995)

The digestibility of the different nutrients (OM, CP, EE, CF, NFE) were estimated using the following formula:

$$\text{Digest. of nutrient} = 100 - 100 \times \frac{\text{\% indicator in feed} \times \text{\% nutrient in feces}}{\text{\% indicator in feces} \times \text{\% nutrient in feed}}$$

(Cho *et al.*, 1982)

**6-Biochemical parameters:**

Total serum protein, albumin, globulin, glucose, total lipids, triglycerides, total cholesterol, blood urea nitrogen and blood serum minerals were determined using standard kits supplied by Bio-Merieux (Baines/France). T3 & T4 were measured by using microwell reader and EIA test kit supplied by Medix Biotech. INC., after Schall *et al.* (1978).

**7- Ultrasonography examination:**

Throughout the period of the experiment, the animals were examined regularly twice weekly using Ultrasonography in the manner described for dromedary camels (Tibary and Anouassi, 1996). The equipment used was a real time, B-mode scanner fitted with 6/8 MHz linear probe (Pie Medical Scanner 100 LC, Pie Medical Co., Netherlands). Briefly, after palpation and removal of fecal material, the probe was introduced manually into the rectum using lubricant. The genital tract was scanned slowly over all its parts starting with the cervix, then each uterine horn followed by the ipsilateral ovary.

Data collected during Ultrasonography included number of large (> 15 mm), medium (10-15 mm) and small (<10 mm) follicles. In addition the diameter of the largest (dominant) and second largest (subordinate) follicles were measured to the nearest millimeter using the ultrasound built in the measuring ruler. The Ultrasonographic images were saved on floppy disks using the floppy disk drive attached with the ultrasonographic device.

**8- Statistical analysis:**

Statistical analyses of the collected data were carried out according to procedures of completely random design, SAS (1995).

## RESULTS and DISCUSSION

The comparable diet was formulated from several ingredients of which the wheat straw forming 55.1% and whole mixed altogether resulting in a mixture of 2.17 Mcal ME/kg DM and 21.15% crude fiber. In the low energy diet, the amount of wheat straw reached 82.1% giving rise to a high fiber (30.09%) and low energy (1.75 Mcal/kg DM). In high-energy diet, the percent of concentrates increased, and the straw decreased (25.10%) resulting in a diet low in fiber (11.45%) and high in energy (2.61 Mcal/kg DM).

**1-Dry matter intake:**

The mean values of daily dry matter intake for animals in the experimental trials are presented in Table (3). Dry matter intake was significantly ($P<0.05$) high for camels fed on the high-energy diet (6.23 kg/h/d) compared to low energy (5.13 kg/h/d) and comparable (5.98kg/h/d) diets. The reduction in dry matter intake comprised 17.66% & 4.01% in low energy & comparable diets respectively than high-energy one. Daily feed intake was found to be increased along with the increase in the energy level (Singh *et al.*, 1991; Bhavani *et al.*, 1997; Chauhan *et al.*, 1997; Salkala & Baruah, 1997; Mahgoub *et al.*, 2000 and Haenlein, 2002). Jindal (1979) found that DMI was significantly higher in 20% higher energy level than normal in growing goats, while Harmon & Britton (1983) reported that dry matter intakes increased with each increase in dietary concentrate in lambs.

**2- Digestion coefficient of nutrients:**

The chemical composition of fecal matter excreted and mean digestion coefficients of dry matter, organic matter, crude protein, ether extract, crude fiber, NFE, calcium and phosphorus are presented in Tables (4 & 5) and figure (1).

Camels fed on the high-energy diet recorded significantly ($P<0.05$) higher values (65.65 & 66.71%) compared to the other two trials (57.14 & 58.48%; 61.86 & 63.37%) for dry matter and organic matter digestibilities. High energy diet increase 8.51 and 8.23 percent units in the dry matter and organic matter digestibility than low energy diet. The obtained results supported by Mahgoub *et al.* (2000) who found that increasing the energy level of the diet from low then medium to high resulted in increased DM digestibility.

For crude protein, ether extract, crude fibre and NFE digestibilites, camels fed on high energy diet recorded significantly ($P<0.05$) higher values (73.12, 74.76, 58.09 & 67.01% respectively) compared to low energy diet (62.02, 63.27, 52.93 & 61.6% respectively). Factorially, it is 11.1, 11.49, 5.16 & 5.41 percent units increase in CP, EE, CF & NFE digestibilites than low energy diet. In the high-energy diet, the digestibilities of CF and NFE were increased because of the richness of the diet in NFE and its low CF compared with the other two trials.

Similar results were obtained with other animals in the previous studies (Jindal *et al.*, 1979; Kishan *et al.*, 1981 and Hemanalini *et al.*, 1999) who reported that DM, OM, CF, CP, EE and NFE increased significantly with increasing energy levels in the diets of goats and lambs. In addition, high-energy diet was superior to low or medium energy in view of the better digestibility and utilization of nutrients

Increasing energy in the diet of camels had significantly ($P<0.05$) effect on the availability of calcium and phosphorus (40.83, 39.19%) compared to the other two trials (32.02, 26.98, 35.17 & 29.94%). This agreed with that found by Rayssiguier & Poncet (1980) and Funaba *et al.* (1990) who pointed out that readily fermenTable carbohydrate increased apparent digestibility of both Ca & P by sheep. Singh *et al.* (1979), Kishan *et al.* (1981) and Rosero *et al.* (1983) found that, the apparent retention of Ca & P were increased with increasing energy levels in the ration of sheep and goats. In addition, Braithwaite (1976) reviewed that Ca & P availability were reduced in sheep given low energy diet.

## 3- Biochemical parameters:

### 3.1- Serum protein:

The total serum protein, albumin and globulin values revealed no significant differences ($P<0.05$) among the animals fed on the comparable (6.9, 3.8 & 3.0 g%) and high energy diets (7.10, 4.20 & 3.50 g%), while camels fed on the low energy diet recorded significantly ($P<0.05$) lower values (6.2, 3.4 & 2.6 g%, respectively) as shown in Table (6).

### 3.2- Blood glucose:

The serum glucose revealed higher significant ($P<0.05$) values in camels fed on high energy diet (72 mg%) than the values of comparable (64 mg%) and low energy ones (56 mg%) as shown in Table (6) and figure (2). Increased glucose availability is one of the "immediate nutrient" affects on ovulation rate (Teleni *et al.*, 1989). Low levels of blood glucose are found in association with poor fertility (Richards *et al.*, 1987; Plym Forshell *et al.*, 1991). The availability of oxidizable metabolic fuels, such as glucose may influence activity of neurons that control LHRH release (Schillo, 1992). Therefore, the relationship between glucose and fertility may become significant only if the concentration of glucose in the blood fall below normal limits.

Cows with an adequate energy balance were inseminated earlier and in addition to that, the pregnancy rate at first insemination was better and they needed fewer insemination per pregnancy than did cows with low energy (Miettinen, 1991). The pregnancy rate was significantly higher among cows with high than among cows with low plasma glucose concentrations (Petrson *et al.*, 1992). Butler & Smith (1989) reported that lower availability of glucose may also decrease LH pulsatility or limit ovarian responsiveness to gonadotropins.

**3.3- Serum lipids:**

There were no significant differences ($P<0.05$) in the serum total lipids between camels fed on high energy (348.8 mg%) and comparable ones (342.6 mg%), while camels fed on low energy diet recorded significantly ($P<0.05$) lower value (335.8 mg%) as shown in Table (6) and figure (2).

The serum triglycerides and total cholesterol recorded a higher significant ($P<0.05$) values in camels fed on high energy diet (60.3 & 125 mg%) than the values of comparable (45.8 & 115 mg%) and low energy (38.6 & 100 mg%, respectively) diets. Numerous studies reported that supplemental fat have been used to increase energy density of the diet improved key reproductive parameters such as decreased days to first service, decreased services per conception, increased conception rate and decreased days open (Staples & Thatcher, 1999). Grummer and Carrol (1988) reviewed the possible roles of dietary lipid on ovarian function and the cholesterol can be used as one of the precursors for steroid hormone synthesis. It has been suggested that improved energy status (Hightshoe *et al.*, 1991; Sklan *et al.*, 1994) increased cholesterol availability which enhance ovarian activity. Increased plasma cholesterol concentrations could stimulate progesterone production, although plasma cholesterol is not thought to be rate limiting to ovarian steroidogenesis.

**3.4-Blood urea nitrogen:**

The mean values of blood urea nitrogen in the camel's serum fed on the comparable (16.6 mg%) and high energy (16.9 mg%) diets were significantly ($P<0.05$) higher than in camels fed on the low energy one (15.2 mg%) as shown in Table (6). This may be attributed to the greater efficiency for crude protein digestibility by camels and in conserving food energy and nitrogen by these animals as reported by Barakat &

Abdel-Fattah (1970). According to investigations concerning prediction of reproductive performance on the basis of serum urea and glucose levels, low levels of glucose and/or urea in puerperium were associated with poor fertility (Miettinen, 1991).

**4- Minerals profiles:**

The mean serum concentrations of minerals for animals in the experimental trials are presented in Table (7) and figure (3). Serum concentrations of sodium, chlorine, potassium (mEq/L), calcium, phosphorus and magnesium (mg%) were significantly ($P<0.05$) higher in the serum of camels fed on the high energy (190, 153, 8.9, 13.7, 9.66 & 4.63) and comparable ones (175, 130, 7.8, 11.8, 7.62 & 3.58) compared to the low energy (140, 100, 5.2, 9.10, 5.3 & 2.40, respectively). However, serum calcium and phosphorus were increased significantly during highest ovarian activity in camels as reported by Shehata & Zaghloul (1988). Osman *et al.* (1970) & Shehata (1983) recommended that serum calcium decreased significantly in cattle and buffaloes with inactive ovaries. In addition, Moustgard (1972) found that failure of oestrus in mature animals is the usual symptoms of phosphorus deficiency. The role played by phosphorus deficiency in reproduction is to be a blocking in the function of the pituitary gland and consequently the ovaries (Zintzen, 1972).

**5- Growth hormone:**

The mean serum concentrations of total T3 (ng/dl) and T4 (µg/dl) in camels fed on the comparable (2.80 & 1.80) and high energy (2.75 &1.70) diets were significantly ($P<0.05$) lower than in camels fed on the low energy diet (2.95 & 2.30, respectively) as shown in Table (7). Concentrations of growth hormone (GH) in blood are increased by low energy. In addition, GH increased the number of medium size follicles and decreased the number of large follicles (Lucy *et al.*, 1992). The overall effect is that GH reduces the functional significance of a dominant follicle through augmented low energy and subsequent decreased secretion of LH (Beam, 1996).

**6- Ultrasonography examination:**

**Number and diameter of follicles:**

She-camels studied here showed a continuous and overlapping follicular waves. The follicular wave could be characterized into 4 phases: follicular growth phase during which group of small follicles (2-5) was observed and increased in size to reach 5-8 mm. The second maturation phase corresponded to the development of a single dominant follicle in expense of other follicles. The selection of dominant follicle was followed by a phase of growth averaging an increase in diameter of 6.14 ± 0.15 mm each 3 days during this phase. The follicle continued to grow by this rate to reach a maximum size of about 14.3- 38.01 mm diameter at which they underwent atresia, the third phase corresponded to the follicular regression during which the follicle started to undergo obliterative atresia. A period of no activity is followed where the ovary appeared static (stage of Quiescence).

Most investigators have concluded that waves of follicular growth, maturation and atresia occurred throughout the breeding season in she camel but the time-course of such events can vary with latitude, stage of the season, age and nutritional status of the camels (El-Wishy, 1987 and 1988).

Number of large and medium sized follicles were increased significantly ($P<0.01$) during the trials of feeding on comparable and high energy diets, whereas number of small follicles was greater during the trial of low energy diet (Table, 8) and Figures (4 & 6).

Comprehensive studies on follicular dynamics are lacking in the dromedary camel although studies of this nature have been carried out by Adams et. al. (1990) in the related camelids, the llama (Llama glama) using transrectal ultrasound scanning. This species is also an induced ovulator and it exhibited similar waves of follicular growth, maturation and atresia compared to those reported in the camel. Early in the development of the follicular wave, several small follicles grow but became dominant leading to an inverse relationship between follicle numbers and the diameter of the largest follicle, a matter which is coincide with the present results.

A significant ($P<0.05$) increase in the size of the largest follicle and second largest follicle was recorded during the trial of feeding high energy diet compared with trials in which animals were fed on low energy or comparable ones (Table, 9) and Figures (5 & 7).

There was an inverse relationship between the number of small follicles and the diameter of the largest follicle during the trial of low energy ration. Consequently, this may explain the significant increase in the diameter of the largest follicle with lower number of small follicles during the trial of high-energy diet. Lucy *et al.* (1991b) reported that amplitude of LH pulses as well as diameter and number of the dominant follicles increased with more positive energy. In addition, cows placed on low energy before ovulation had preovulatory follicles that grew more slowly than follicles in cows that were on high energy (Lucy *et al.*, 1990). Beam (1996) reported that low energy content increases the number of medium but decreases the number of large follicles and reduces function of corpora lutea and in addition, altered the metabolic and hormonal status of cows.

In cattle, analysis of data from a larger group of early postpartum cows, in which follicular development and energy balance were measured also indicated that increased energy balance was associated with movement of follicles into larger size classes (Lucy *et al.*, 1991c). It seems to be the same in she-camels fed high-energy diets as the follicles were greater in size than follicles in she-camels fed control or low energy diets. Moreover, the average size of pre-ovulatory follicles was not significantly greater in she-camels fed control diets than she-camels fed low energy diets. In addition, Cows fed high energy diets produced more good oocytes than did cows fed low energy diets (Kendrick *et al.*, 1999).

The additional dietary energy stimulated the development of follicles and led to larger ovarian follicles in cows. In cattle, a reduction in energy balance associated with bST stimulated recruitment of small follicles on the ovary during the first follicular wave, so that the inhibition of growth of subordinate follicles is reduced (Lucy *et al.*, 1992). Chronic negative energy balance causes a linear decrease in the maximum diameter of successive dominant follicles, eventually resulting in anoestrus due to suppressed LH pulse frequency in the final estrus cycle before ovulation (Diskin *et al.*, 1999).

A harmful effect of low energy level on ovarian activity was recorded with previous reports (Butler *et al.*, 1981; Eldon *et al.*, 1988; Huszenicza *et al.*, 1988; Miettnen, 1990). Lucy *et al.* (1991c) reported that ovarian function and follicular size were affected by energy balance. There are significant deviations from the normal patterns of follicular dynamics that may be related directly to energy balance and most noTable of these are short estrous cycles (Morrow *et al.*, 1969) and follicular and luteal cysts (Kesler & Garverick, 1982). Energy deprivation during 19 days before a synchronized estrus did not significantly affect the proportion of goats coming into estrus, but did decrease ovulation rate and delayed timing of ovulation (Mani *et al.*, 1992).

In conclusion, energy had a significant effect on the nutrient utilization and on the follicular development in she-camels, probably, the level of energy in the diet is crucial for the quality of the oocyte and may affect its ability for fertilization. More investigations are needed to prove this concept.

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**Table 1:** Chemical composition (%) of the feed ingredients used in the diets.

| Ingredients | DM | % on DM basis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | CP | EE | CF | Ash | NFE | Ca | P | ME* |
| Corn, ground | 89.0 | 9.4 | 4.2 | 2.80 | 1.8 | 81.8 | 0.03 | 0.31 | 3.11 |
| Soybean meal | 91.5 | 47.0 | 2.5 | 6.50 | 7.2 | 36.8 | 0.36 | 0.75 | 3.15 |
| Wheat bran | 90.0 | 16.8 | 4.8 | 12.60 | 6.8 | 59.0 | 0.12 | 1.32 | 2.67 |
| Wheat straw | 93.0 | 3.6 | 0.5 | 35.0 | 18.0 | 42.9 | 0.21 | 0.08 | 1.60 |
| Limestone | 96.0 | --- | --- | --- | 100 | --- | 36.0 | 0.02 | --- |
| Mon. sod.phosp.* | 98.0 | --- | --- | --- | 100 | --- | --- | 25.8 | --- |
| Mineral mixture | 94.0 | --- | --- | --- | 100 | --- | 0.05 | 0.02 | --- |

*Metabolizable energy, Mcal/kg DM, monobasic sod.phosphate.

**Table 2:** Physical & chemical composition (%) of the experimental diets.

| Ingredients | Experimental diets | | |
|---|---|---|---|
| | 1<br>Low energy | 2<br>Comparable | 3<br>High energy |
| **Physical comp.:** | | | |
| Corn, ground | --- | 32.0 | 65.0 |
| Soybean meal | 9.00 | 5.0 | --- |
| Wheat bran | 6.00 | 5.0 | 7.0 |
| Wheat straw | 82.10 | 55.10 | 25.10 |
| Limestone, ground | 0.55 | 0.70 | 0.9 |
| Mono. sod.phosp | 0.35 | 0.20 | --- |
| Common salt | 1.00 | 1.00 | 1.0 |
| Min.mixt.* | 0.20 | 0.20 | 0.20 |
| $AD_3E$** | 0.30 | 0.30 | 0.30 |
| Chromic oxide | 0.50 | 0.50 | 0.50 |
| **Chemical comp.:** | | | |
| Dry matter (%) | 92.76 | 91.63 | 90.29 |
| Organic matter (%) | 82.08 | 86.95 | 92.01 |
| Crude protein (%) | 8.20 | 8.18 | 8.19 |
| Ether extract (%) | 0.93 | 1.99 | 3.20 |
| Crude fiber (%) | 30.09 | 21.15 | 11.45 |
| NFE (%) | 42.86 | 55.63 | 69.17 |
| Ash (%) | 17.92 | 13.05 | 7.99 |
| Calcium (%) | 0.41 | 0.40 | 0.41 |
| Phosphorus (%) | 0.30 | 0.30 | 0.30 |
| ME (Mcal/kg DM) | 1.75 | 2.17 | 2.61 |

*Mineral mixture: Each 100g contain; 25.6g Na, 1.6g K, 4.6g Ca, 1.8g P, 4g Mg, 300mg Fe, 32mg Mn, 1.5mg Cu, 15mg I, 5mg Zn, 1mg Co & 1mg Se (AGRICO-International Company).

**AD3E: Each gram contains; 20.000 IU vit.A, 2000 IU vit.D & 400 IU vit.E (AGRICO- International Company).

**Table 3:** Dry matter intake of the animals during the experimental trials.

| Diets | Dry matter intake kg/ head/day |
|---|---|
| 1 (Low energy) | 5.13±0.22 [c] |
| 2 (Comparable) | 5.98±0.25 [b] |
| 3 (High energy) | 6.23±0.33 [a] |

*Figures in the same row having the same superscripts are not significantly different (P<0.05).

**Table 4:** Chemical composition (% on DMB) of fecal matter.

| Items | Experimental trials | | |
|---|---|---|---|
| | 1 Low energy | 2 Comparable | 3 High energy |
| OM | 79.52±1.04 | 83.52±1.24 | 89.16±1.50 |
| CP | 7.27±0.42 | 6.58±0.25 | 6.41±0.19 |
| EE | 0.81±0.09 | 1.53±0.08 | 2.35±0.30 |
| CF | 33.04±1.12 | 23.73±2.12 | 13.97±1.75 |
| NFE | 38.40±1.65 | 51.68±1.86 | 66.43±2.50 |
| Ash | 20.48±0.81 | 16.48±0.81 | 10.84±0.65 |
| Ca | 0.65±0.07 | 0.68±0.04 | 0.71±0.06 |
| P | 0.51±0.08 | 0.55±0.05 | 0.53±0.04 |
| $Cr_2O_3$ | 1.05±0.07 | 1.18±0.03 | 1.31±0.05 |

**Table 5:** Digestion coefficient (%) of nutrients during the experimental trials.

| Items | Experimental trials | | |
|---|---|---|---|
| | 1 Low energy | 2 Comparable | 3 High energy |
| Dry matter | 57.14±3.09 [b] | 61.86±1.12 [ab] | 65.65±1.57 [a] |
| Organic matter | 58.48±2.94 [b] | 63.37±0.94 [ab] | 66.71±1.84 [a] |
| Crude protein | 62.02±3.37 [b] | 69.32±1.75 [a] | 73.12±2.61 [a] |
| Ether extract | 63.27±4.66 [b] | 70.70±3.51 [a] | 74.76±1.65 [a] |
| Crude fiber | 52.93±0.94 [b] | 57.22±1.86 [ab] | 58.09±3.69 [a] |
| Nitrogen free extract | 61.60±4.28 [b] | 64.56±2.07 [b] | 67.01±2.10 [a] |
| Calcium | 32.02±2.15 [b] | 35.17±4.77 [b] | 40.83±1.23 [a] |
| Phosphorus | 26.98±1.76 [b] | 29.94±4.42 [b] | 39.19±2.71 [a] |

*Figures in the same row having the same superscripts are not significantly different (P<0.05).

**Table 6:** Blood serum biochemical changes of she-camels during the experimental trials.

| Items | Experimental trials | | |
|---|---|---|---|
| | 1<br>Low energy | 2<br>Comparable | 3<br>High energy |
| Total protein (g%) | 6.2±0.18 [b] | 6.9±0.21 [a] | 7.10±0.20 [a] |
| Albumin (g%) | 3.4±0.08 [b] | 3.8±0.05 [a] | 4.20±0.15 [a] |
| Globulin (g%) | 2.6±0.01 [b] | 3.0±0.05 [a] | 3.5±0.02 [a] |
| Glucose (mg%) | 56.0±1.50 [c] | 64.0±1.10 [b] | 72.0±1.20 [a] |
| Total lipids (mg%) | 335.8±6.10 [b] | 342.6±7.05 [a] | 348.8±6.50 [a] |
| Triglyceride (mg%) | 38.6±2.90 [c] | 45.8±2.50 [b] | 60.3±3.10 [a] |
| Total cholesterol (mg%) | 100.0±3.50 [c] | 115.0±2.70 [b] | 125.0±4.14 [a] |
| B.U.N (mg%) | 15.2±1.10 [b] | 16.6±0.15 [a] | 16.9±0.10 [a] |

*Figures in the same row having the same superscripts are not significantly different (P<0.05).

**Table 7:** Minerals profile and growth hormones of she-camels during the experimental trials.

| Items | Experimental trials | | |
|---|---|---|---|
| | 1<br>Low energy | 2<br>Comparable | 3<br>High energy |
| Sodium (mEq/L) | 140±11.10 [b] | 175±10.15 [a] | 190±14.12 [a] |
| Chlorine (mEq/L) | 100±12.10 [b] | 130±13.05 [a] | 153±10.90 [a] |
| Potassium (mEq/L) | 5.2±0.80 [b] | 7.8±0.96 [a] | 8.9±0.57 [a] |
| Calcium (mg%) | 9.10±0.90 [b] | 11.8±0.87 [a] | 13.7±0.75 [a] |
| Phosphorus (mg%) | 5.30±0.87 [b] | 7.62±0.80 [a] | 9.66±0.50 [a] |
| Magnesium (mg%) | 2.40±0.40 [b] | 3.58±0.63 [a] | 4.63±0.80 [a] |
| T3 (ng/dl) | 2.95±0.10 [a] | 2.80±0.06 [b] | 2.75±0.05 [b] |
| T4 (µg/dl) | 2.30±0.07 [a] | 1.80±0.05 [b] | 1.70±0.02 [b] |

*Figures in the same row having the same superscripts are not significantly different (P<0.05).

**Fig.1.Effect of different energy levels on the digestion coefficients of DM, CP & CF**

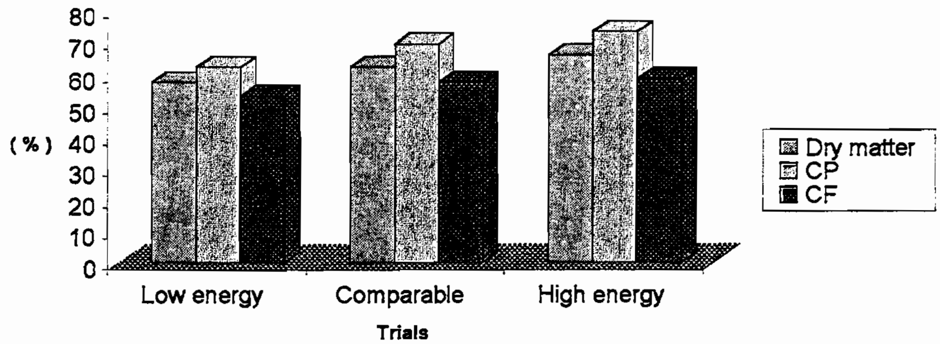



**Fig.2. Effect of different energy levels on the serum glucose, triglycerides and cholesterol concentrations**

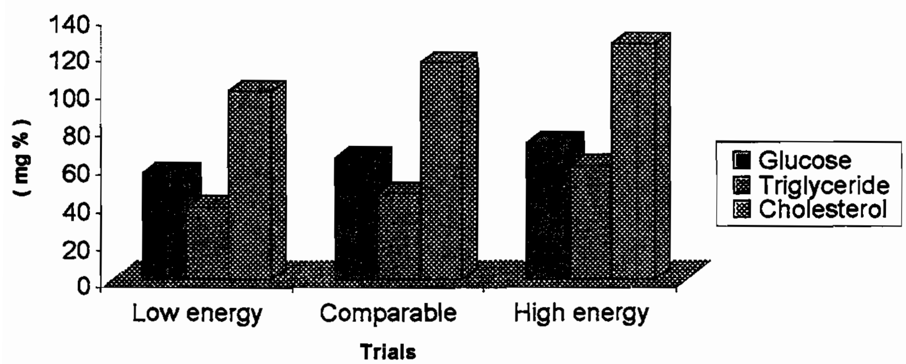
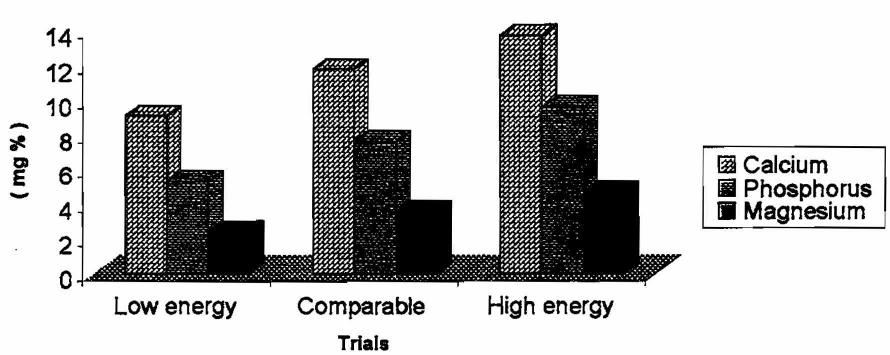



**Fig.3.Effect of different energy levels on the serum calcium, phosphorus and magnesium concentrations.**



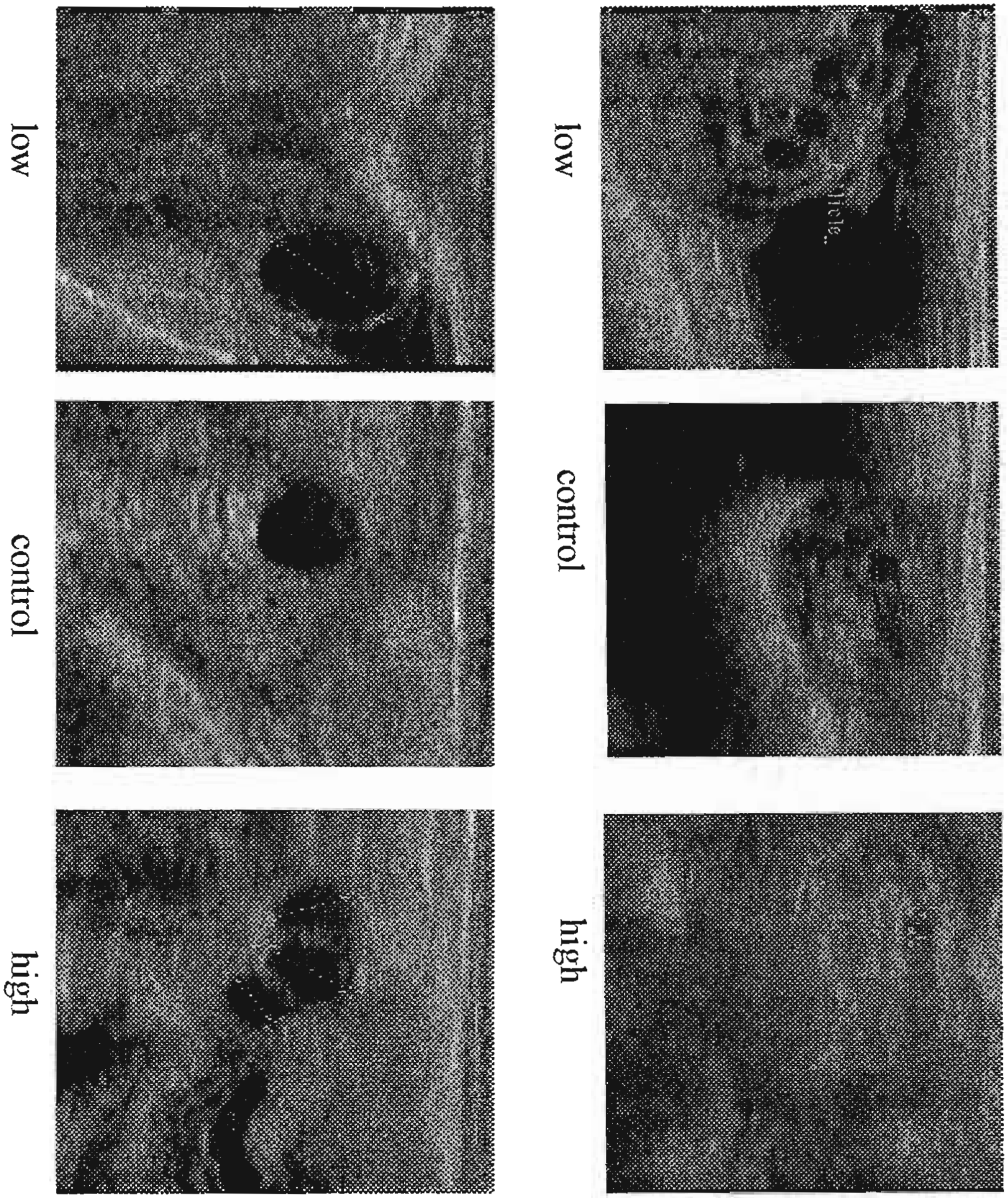



Fig. 4. Number of small (Upper row) and medium (lower row) follicles in low, control and high energy diets fed she-camels.

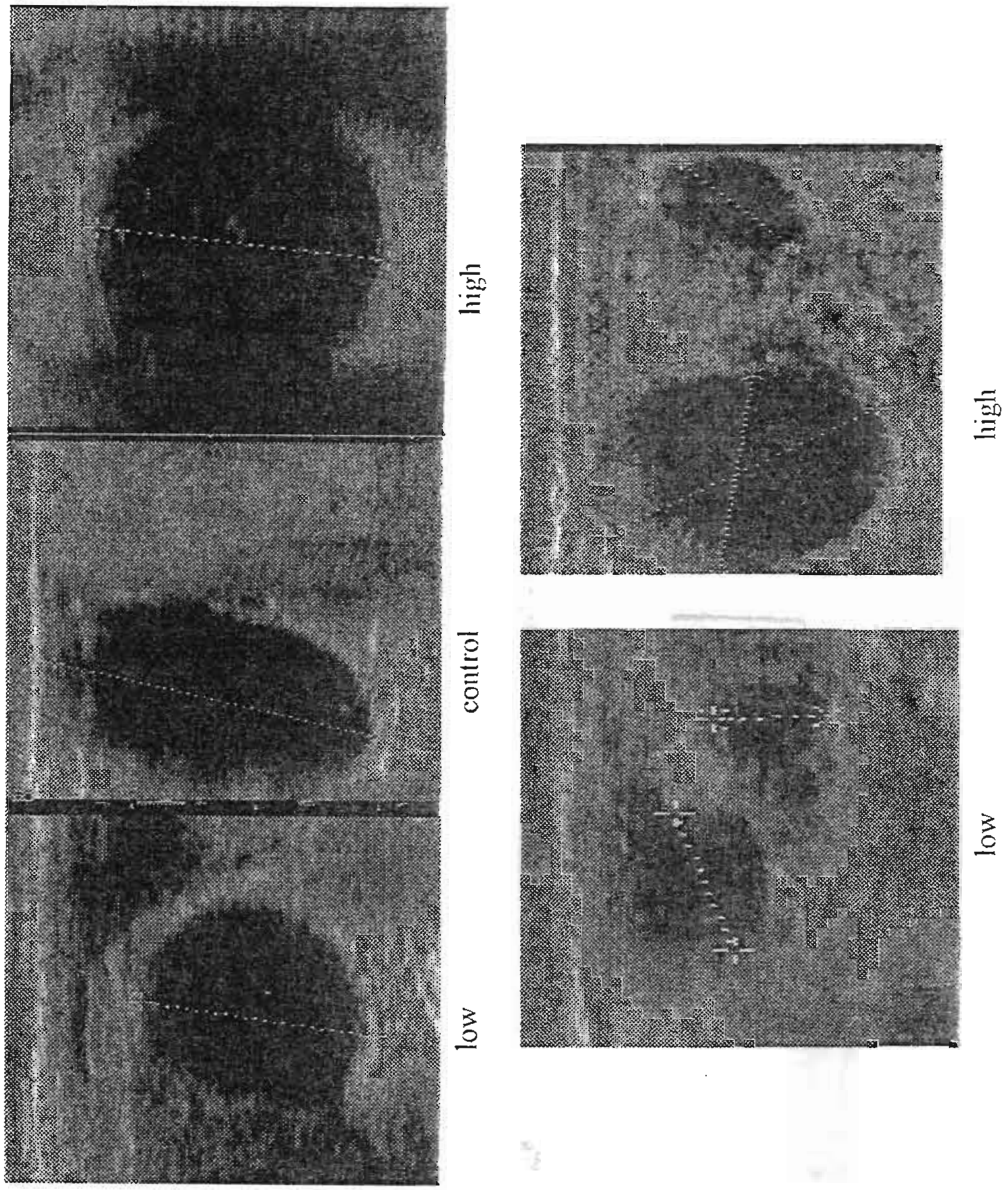



Fig.5. Changes in the size of largest (dominant, upper row) and second largest (subordinate, lower row) follicles after low, control and high energy diets in she-camels.

**Fig.6.Effect of different energy levels on the number of large, medium and small follicles**

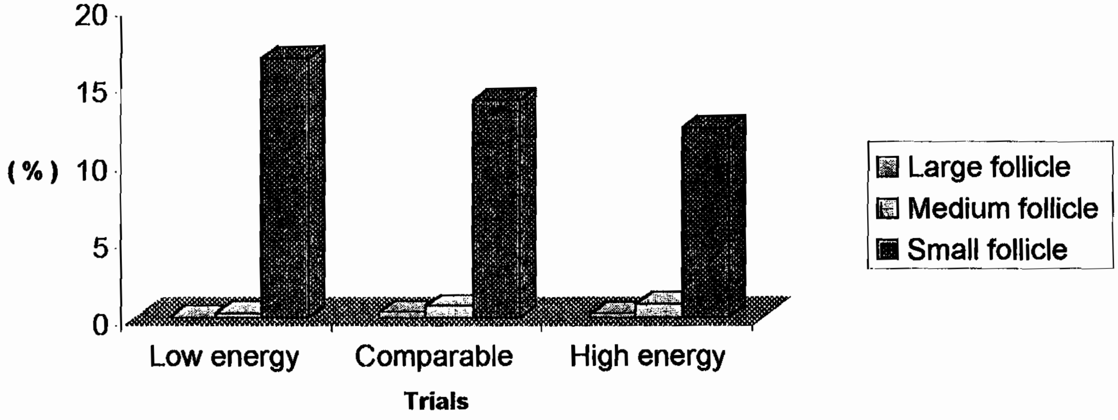



**Fig.7. Effect of different energy levels on the size of dominant and subordinate follicles.**