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INFLUENCE OF FEEDING DIFFERENT LEVELS OF VEGETABLE FAT ON THE NUTRIENTS UTILIZATION, RUMINAL FERMENTATION AND SOME BLOOD BIOCHEMICAL PARAMETERS IN MALE GOATS

(With 11 Tables and 3 Figures)

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تأثير إضافة مستويات مختلفة من الدهون النباتية علي مدي الاستفادة من العناصر الغذائية وتخمر الكرش وبعض التغيرات البيوكيميائية في مصل دم ذكور الماعز

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فـي هـذه التجربة تم استخدام عدد ١٢ من ذكور الماعز البلدية متوسط أعمارها ٤ سنوات وتراوح وزنها من ٢٢ إلى ٢٣ كجم لدراسة تأثير إضافة الدهون النباتية (زيت النخيل) علي كمـية الأكل ومعاملات الهضم والاتزان النيتروجيني وتخمر الكرش بالإضافة إلى التغيرات البيوكيميائية لمصل الدم في الماعز خلال فترة التجربة التي استغرقت ٣٥ يوما. وقد قسمت هـذه الحيوانات إلى أربعة مجموعات (٣ حيوانات/مجموعة). غذيت المجموعة الأولى علي العليقة الضابطة (بدون إضافة زيوت) بينما غذيت المجموعات الثانية والثالثة والرابعة علي العلائق المزودة بالزيوت بنسبة ٢%, ٤% و ٦% علي التوالي. كل العلائق المختبرة احتوت علـي ٢,٥ ميجاكالوري طاقة ممثلة/كجم عليقة جافة و ٩,٦% بروتين خام طبقا لاحتياجات الماعـز الموصـي بها في NRC. وقد أوضحت النتائج أن زيادة مستويات الدهون النباتية المضـافة إلـى علائـق الماعز أدي إلى نقص معنوي في كمية المادة الجافة المأكولة وقد اسـتهلكت المجموعـة الضـابطة كمـية أكبر من المادة المأكولة (٦٤٩ جم/رأس/يوم) مع انخفـاض معـدل التحويل الغذائي مقارنة بالمجموعات المغذاة علي علائق مزودة بالدهون النباتية (٥٦٦, ٥٤١, ٤٣٣ جم/رأس/يوم). معاملات هضم المادة الجافة والعضوية والألياف قلت معنويا مع أعلي نسبة من الدهون المضافة (٦%) ولكن معاملات هضم البروتين الخام والدهـون زادت معـنويا مع زيادة نسبة الدهون النباتية في علائق كل الحيوانات المختبرة. زيـادة نسـبة الدهون النباتية المضافة للعلائق أدت إلى زيادة معنوية في معدل النيتروجين المخـزن كنسبة من النيتروجين المستهلك أوالممتص في جسم الماعز. إضافة الزيوت أحدث نقـص معـنوي فـي العد البكتيري لميكروبات الكرش وتركيز الامونيا والأحماض الدهنية

الطـيارة فـي الكرش مع زيادة نسبة الإضافة. لم يكن لإضافة الزيوت أي أثر علي كل من بروتيـن الـدم والجلوكـوز بيـنما زادت تركـيزات كل من الدهون الكلية والجليسريدات والكوليسـترول مع إضافة الدهون النباتية إلى علائق الماعز. نستخلص من هذه الدراسة أنه يمكـن إضافة الدهون النباتية إلى علائق الماعز حتي نسبة ٤% بدون أي تأثير علي كل من معـدل الهضـم فـي الكرش ومعدل الاتزان النيتروجيني وبدون أي تغيرات في المكونات البيوكيميائية لمصل الدم بالإضافة إلى الفائدة الاقتصادية.

SUMMARY

Twelve male Baladi kids (4 years old, and body weights ranged from 22 to 23 kg) were used in this experiment to determine the effects of supplemented different levels of vegetable oil (palm oil), on feed intake, nutrient digestibilities, ruminal fermentation, nitrogen balance and blood biochemical parameters in an experiment for 35 days. The animals were allotted into four groups, 3 animals per each. The first group was fed a control diet (no fat supplement), while the second, third and fourth groups were fed on diets containing 2%, 4% & 6% vegetable oil (palm oil) respectively. All experimental diets were formulated to provide the recommended levels of metabolizable energy (2.5 Mcal/kg diet) and crude protein (9.6%) according to NRC for goats. With the increase of fat level in the goats diets, dry matter intake was decreased significantly ($P<0.05$). The control group consumed more dry matter (649g/h/d) compared with the fat supplemented ones (566, 541 & 433 g/h/d for 2%, 4% & 6% respectively). Animal groups fed on the diets supplemented by fat consumed less dry matter but they showed better feed conversion compared to those fed the control diet. The dry matter, organic matter and crude fiber digestibilities were reduced significantly ($P<0.05$) with the high level of fat (6%). Crude protein and ether extract digestibility values were significantly ($P<0.05$) increased as the level of fat increased. Nitrogen balance as % of intake and absorbed were significantly ($P<0.05$) increased as the level of fat supplementation increased. Total viable bacterial count and ammonia concentrations were significantly ($P<0.05$) decreased as the level of fat supplementation increased in the diets, while volatile fatty acids concentration decreased. Blood protein profile and serum glucose were not significantly ($P<0.05$) affected, while total lipids, triglycerides and cholesterol concentrations of serum were significantly ($P<0.05$) increased by fat supplementation. It could be concluded that, palm oil can be added to the diets of goats at a rate of 4% without disturbing digestion in rumen or nitrogen balance or any

change in the blood biochemical parameters in addition to its economical benefit.

Key words: *Vegetable fat, digestibility, N-balance, ruminal fermentation, blood profile, goats*

INTRODUCTION

The huge demand for grains as a main source of energy for livestock and due to steady current competition between mankind and poultry in one side and ruminant in other side, aggressively led nutritionist to replace part of starchy grains by fat. Therefore, partially usage fat as an energy source in ruminant rations has been received growing interest over long years ago (Mostafa *et al.* 1995). Substitution of fat for a grain is a method for increasing energy density without compromising fiber content (Palmquist & Jenkins, 1980; Palmquist & Wiseman, 1984). Fats can be used to increase the energy density of high-forage diets that are fed to ruminants. However, it is believed that the lipid supplied to ruminant diets often has a negative effect on feed intake and fiber digestibility. This effect is more marked with polyunsaturated fatty acids (Palmquist & Jenkins, 1980 and Sutton *et al.*, 1983). Because only 3% to 5% of fat added to common feeds seems to be tolerated by ruminal microorganisms, research has been conducted to develop high fat feeds that do not impair fermentative digestion (Cuitun *et al.*, 1975; Palmquist & Jenkins, 1980; Chalupa *et al.*, 1985 and Grummer, 1988). The use of these fats suggests the potential to employ lipids up to 8 to 9% of the diet dry matter (Ostergaard *et al.*, 1981). Much of the earlier work which indicated that fat affects digestion negatively may not be applicable because of great differences in the nature of diets and fats fed and especially in total feed intake. The uniquely high acidity in the duodenum combined with detergent action of bile acids, lysolecithin and fatty acids causes saturated fatty acids to be more digestible in ruminants than in non-ruminants (Palmquist & Jenkins, 1980). Fats may be added in the form of oil seeds, animals and vegetable fats to provide unsaturated and saturated fatty acids and ruminally protected fatty acids and the currently recommended maximum fat supplementation for ruminants is 6 to 7% of dry matter intake (El-Banna, 1999). Therefore, this study was carried out to provide information about the effect of feeding goats diets supplemented with different levels of fat on the feed intake, digestibility of nutrients, nitrogen balance and ruminal activity in addition to some blood biochemical changes.

MATERIALS and METHODS

1- Animals, housing and feeding:

Twelve male Baladi kids (4 years old, and body weights ranged from 22 to 23 kg) were used in this experiment. The animals were allotted into four groups, 3 animals per each. The first group was fed a control diet (no fat supplement), while the second, third and fourth groups were fed on diets containing 2%, 4% & 6% vegetable oil (palm oil) respectively. All experimental diets were formulated to provide the recommended levels of metabolizable energy (2.5 Mcal/kg diet) and crude protein (9.6%) according to NRC (1981) for goats. The goats received diets based on crushed white corn, soybean meal, wheat bran and wheat straw supplemented with a mineral and vitamin mixture (Tables 1 & 2) Animals were clinically healthy and kept individually in metabolic cages to ease the separate collection of feces and urine throughout the experimental period which extended for 35 days (28 days as a preliminary period followed by 7 days as a collection one). The diets were given twice daily at 9.00 am and 5.00 p.m. and any residues were collected and weighed throughout the experimental period and all animals have free access to clean water. Animals were weighed at the beginning and at the end of the experiment, and feed intake was recorded throughout the experimental period.

2- Samples:

2-1. Feeds, fecal matter and urine:

Feed ingredients which used in the experimental diets were sampled, dried, ground and analyzed for different nutrients. The total amount of the daily fecal matter excreted per animal was collected daily, weighed, recorded, mixed thoroughly throughout the collection period and representative samples (one-fourth) were taken from each animal, dried for 24 hours at 60°C, pooled together, mixed ground and stored till analysis. The volumetric urinary output was collected daily from each animal in plastic containers and recorded, then representative samples (100 ml) were taken, acidified with 2 ml of concentrated HCl as a preservative and then stored in a refrigerator at 4°C for nitrogen determination.

2-2. 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.

2-3. Ruminal juice samples: - Ruminal juice was collected from each animal in clean and sterile flask by using clean and sterile stomach tube. Thirty ml of the ruminal fluid was drawn aseptically into clean and sterile vials to be used for bacteriological examination immediately after collection. The colony forming units/ml of the ruminal juice was carried out by standard plate techniques (Baily & Scott, 1994). At the beginning of incubation, subsamples of rumen content were collected and microbial activities were stopped by adding 10 ml formalin, this was considered as zero time sample which was strained through cheese cloth, 10 ml aliquots of the strained rumen liquor were deprotenizied by adding 10 ml 0.1 N HCl for 20 minutes, distilled water was added to make the final volume of 100 ml. This was filtered and aliquots from the filtrate were used to determine VFAs and ammonia concentrations.

3- Analytical methods:

Feed samples were analyzed according to the official methods of AOAC (1984) for DM, CP, EE, CF and ash. Nitrogen free extract was calculated by difference. Nitrogen content of feces and urine samples were estimated according to AOAC (1984) for calculation of nitrogen balance. Total volatile fatty acids (TVFAs) and ammonia N were determined by gas-liquid chromatography (Intersmat, IGC 120 FB).

4- Calculation of digestion coefficient:

Digestion coefficient of the nutrients for the different experimental diets were calculated by using the direct method.

5- Biochemical parameters:

Total serum protein, albumin, globulin, glucose, total lipids, triglycerides, total cholesterol, uric acid and blood urea nitrogen and blood serum minerals were determined using standard kits supplied by Bio-Merieux (Baines/France).

6- Statistical analysis:

All data were subjected to statistical analysis (SAS, 1990). Duncan's multiple range test were utilized to detect differences among groups.

RESULTS and DISCUSSION

1- Dry matter intake:

The dry matter intake (g/h/d) of the animal groups are presented in Table (3). The dry matter intake by goats decreased significantly ($P<0.05$) as the fat level increase in the diet. The control group

consumed more dry matter (649g/h/d) compared with the fat supplemented groups (566, 541 & 433 g/h/d for 2%, 4% & 6% respectively). The dry matter intake by the fat-supplemented groups decreased by 12.78%, 18.61% & 33.28% at 2%, 4% & 6% respectively. This could be attributed to the significant intensification of energy of fat rations (Mostafa *et al.*, 1995). Similar results were found by Abdel-Hafiz *et al.* (1992) and Hussein *et al.* (1995) who attributed the decrease of dry matter intake to the length of the retention time of feed bulk in the rumen. Feed intake is controlled by the energy content of the ration, if it exceed a certain limit, the feed intake was depressed (Palmquist, 1991; Van Houtert & Leng, 1993). Other previous studies (Mohamed *et al.*, 1988; Johan *et al.*, 1990; Holter *et al.*, 1993; Simas *et al.*, 1995 and Jenkins, 1997) reported that the reduced feed intake of fat supplemented diets may be secondary to inhibition of rumen fermentation (Kowalkzyk *et al.*, 1977), or to slowing of intestinal motility or to taste and palatability factors (Palmquist, 1988). On the other hand, said that feed intake is not affected if fats do not interfere with ruminal fermentation and if precautions are taken to allow the animal to adjust the new flavor and odor and this can be done by introducing fats gradually rather than abruptly. However, some research workers reported that, fat supplementation had no affect on feed intake (Palmquist & Conrad, 1978; Yong *et al.*, 1993, Elliott *et al.*,1993 and Maigo *et al.*, 1995).

2- Growth performance:

The growth performance of the goats in different experimental groups are illustrated in Table (4). Animal groups fed on the diets supplemented by fat consumed less dry matter but they showed better feed conversion (12.95, 11.34 & 11.39) compared to those fed the control one (12.62). Similar result was found by Mostafa *et al.* (1995) and Zinn & Shen (1995) who reported that supplemental fat decreased DMI but increasing feed conversion. The lower growth rate of the animals fed on high level of fat (6%) may be attributed to lower crude protein and energy intake. However, protein conversion efficiency and energetic efficiency were significantly ($P<0.05$) increased as the level of supplemented fat increased.

3- Digestibility of nutrients:

The chemical composition of the fecal matter of the different animal groups are presented in Table (5). Digestion coefficients of different nutrients for goats fed on the control and fat-supplemented diets are illustrated in Table (6).

3-1. Dry matter & organic matter digestibility:

The dry matter and organic matter digestibilities were reduced significantly ($P<0.05$) with the high level of fat (6%). Factorially, it is 8.3 and 7 percent units decrease in dry matter and organic matter digestibilities than control group. Similar results were obtained by previous studies (Jenkins & Fotouhi, 1990; Zinn & Shen, 1995 and Febel *et al.*, 2002) who reported that fat added to the diet regardless of source, reduced digestibilities of dry matter and acid-detergent fiber. Fat supplementation of ruminant-based diets was accompanied by a decrease in organic matter digestibility mainly due to decreased fiber digestion in the rumen (Ben-Salem *et al.*, 1993). However, Hussein *et al.* (1995) reported that dry matter digestibility was as expected higher when the animals were fed diets supplemented with fat. Available reports indicate that addition of fat up to 7% in the diets depressed dry matter and fiber digestibilities by steer (Jenkins & Palmquist, 1984; Bendary *et al.*, 1994), but not by sheep (Dijkstra, 1969) or lactating dairy cows (Palmquist & Conrad, 1980; Jenkins & Palmquist, 1984).

3-2. Digestibility of crude protein:

For crude protein digestibility, the results revealed that crude protein digestibility improved by fat supplementation as there were significant ($P<0.05$) differences between control group and that supplemented groups. Similar results were found by some authors (Palmquist & Conrad, 1980; Hussein *et al.*, 1995) who found the addition of fat to the diet of sheep had significant effect on crude protein digestibility. However, Zinn & Shen (1995) stated that addition of fat to the diet of steer had no significant effect on the digestibility of nitrogen.

3-3. Ether extract digestibility:

Ether extract digestibility values were significantly ($P<0.05$) increased as the level of fat increased in the diets of experimental animals. With high level of fat (6%), ether extract digestibility was increased by 9.4 percent units than control. It has been noted in several previous studies that, the inclusion of lipid into the diets increased fat digestibility (Brumby *et al.*, 1978; Sharma *et al.*, 1978; Jenkins & Palmquist, 1984; Bayourthe *et al.*, 1993). The higher digestibility of fat associated with fat supplementation might be due to the higher digestibility of the supplementary fat and in line the smaller effect of endogenous lipid excretion on apparent fat digestibility (Brumby *et al.*, 1977; Sharma *et al.*, 1978; Palmquist & Conrad, 1978 & 1980; Honing *et al.*, 1981; Abel *et al.*, 1988 and Ryanto, 1989).

3-4. Crude fiber digestibility:

Crude fiber digestibility was significantly ($P<0.05$) decreased with the high level of fat (6%) in the diets of goats. Factorially, it is 2.9 and 9.2 percent units decrease in fiber digestibility at high level of supplemented fat (4% & 6% respectively) than control. The addition of fat to ruminant diets depressed fiber digestibility in cattle (Palmquist & Jenkins, 1980; Harfoot & Hazlewood, 1988; Church, 1991; Eastridge & Frinkins, 1991 and Abd El-Hafeez *et al.*, 2002) and sheep (Magdus *et al.*, 1992; Jenkins, 1997). This may be attributed to that physical coating of fiber with fat preventing microbial attack and inhibition of microbial activity from surface-active effect of fatty acids on cell membrane (Demeyer & Van Nevel, 1995). The depression in crude fiber digestibility was found at higher level of fat supplementation, but at low levels, crude fiber digestibility hardly changed or even increased (Honing *et al.*, 1981). In contrast, Doreau *et al.*(1991) reported that digestion of fiber components found not to be affected by vegeTable oil (Doreau *et al.*, 1991).

3-5. Calcium and phosphorus digestibility:

The digestibilities of calcium and phosphorus were affected significantly ($P<0.05$) by supplementation of fat to the diets of goats. Similar results were found with previous studies (Palmquist & Conrad, 1978; Rahnema *et al.*, 1994; Zinn & Shen, 1995) who reported that feeding supplemental fat to ruminants reduced digestibility of calcium and fatty acids can form insoluble soaps with cation in the rumen which reduce Ca absorption (Sukhija & Palmquist, 1990), while Sharma *et al.* (1978) stated that fat had no effect on the digestibility of Ca & P.

4- Nitrogen balance: -

Table (7) presented the results of the nitrogen balance of the experimental groups. The N intake (g/day) was the minimum in animals of group fed on the 6% fat (6.65 g/day) compared to other treated groups (8.68 & 8.32 g/day) and control (9.95 g/day). Nitrogen excretion in both fecal and urine was significantly ($P<0.05$) decreased as the level of fat increased. Absorbed nitrogen was significantly ($P<0.05$) decreased as the level of fat supplementation increased. Nitrogen balance as % of intake and absorbed were significantly ($P<0.05$) increased as the level of fat supplementation increased. Similar result was found by Bayourthe *et al.* (1993) who reported that nitrogen retention was significantly higher in the sheep fed on diets supplemented with fat relative to the basal diets due to decrease in the fecal and urinary excretions.

5- Ruminal parameters:

5-1. Total bacterial count: -

Supplementation of fat to the goat diets has a great effect on the decreased total viable bacterial count in the rumen compared to the control group as shown in Table (8). The mean colony forming unit (CFU) in the ruminal juice was 1.4×10^5 in the animals group fed on 6% supplemented fat compared to 5×10^9 in the control one. Similar results were found by Ikwuegbu & Sutton (1982) and Hussein *et al.* (1995) who reported that fat supplementation reducing bacterial number inside the rumen.

5-2. Total volatile fatty acids concentration: -

Average of volatile fatty acids concentration (meq/100 ml R.L) in the rumen liquor of goats fed on the different experimental diets are presented in Table (8). Total VFAs concentration was significantly ($P<0.05$) decreased with the high level (6%) of fat supplementation. The decrease in TVFAs concentration may be due to the passive effect of fat on the fiber digestion or to less fermenTable organic matter in the fat-diets (Magdus *et al.*, 1992 and Pantoja *et al.*, 1994). This result agreed with that found by Elliott *et al.* (1993); Hussein *et al.* (1995) and Jenkins (1997) who reported that VFAs concentration was reduced by high fat inclusion in the diet. In contrast, others stated that total concentration of VFAs was not affected by fat supplementation (Grummer, 1988; Schauff & Clark, 1989; Ohajuruka *et al.*, 1991; Palmquist, 1991, Drackley & Elliott, 1993 and Palmquist *et al.*, 1993).

5-3. Ammonia concentration: -

Ammonia concentration average (mg/100 ml R.L) in the rumen of goats fed on the different experimental diets are presented in Table (8). Ammonia concentration was significantly ($P<0.05$) decreased as the level of fat supplementation increased in the diets. Similar results were reported by previous studies (Kowalczyk *et al.*, 1977; Ikwuegbu & Sutton, 1982; Jenkins & Fotouhi, 1990; Hussein *et al.*,1995 and Drochner & Yildiz, 1999).

6- Blood biochemical changes:

The blood biochemical changes of the different experimental groups are presented in Table (9).

6-1. Blood protein profile:

Total protein, albumin, globulin and blood urea nitrogen concentrations of serum in the different experimental goats groups were

non significantly (P<0.05) affected by supplementation of fat to the diets.

6-2. Blood glucose:

There was no significant differences (P<0.05) in the concentration of serum glucose between different experimental groups. The control group had 55 mg%, while the level in fat supplemented groups ranged from 52 to 56 mg%. Similar results were obtained (Palmquist & Conrad, 1978 and DePeters *et al.*, 1989). On the contrary, Magdus *et al.* (1992) reported that serum glucose was decreased by fat supplementation.

6-3. Blood lipid profile:

Total lipids concentration of serum were significantly (P<0.05) increased by fat supplementation. With the high level of supplementation (6%), total serum lipid increased by 6.32% compared to the control. The results seemed to be supported by Palmquist & Conrad (1978); Yang *et al.* (1978); Selner & Schultz (1980); Gaynor *et al.* (1994); Abd El-Hafeez *et al.* (2002) and Febel *et al.* (2002).

With the addition of fat, the concentration of serum triglycerides was increased significantly (P<0.05). This agreed with what is reported by Palmquist & Conrad (1978); Lough *et al.* (1994) and Febel *et al.* (2002).

The level of serum cholesterol was significantly (P<0.05) increased with fat supplementation and increased by 14.29 & 23.81% in 4% & 6%. Similar results were obtained in the previous studies by (Jenkins & Jenny, 1989; Lough *et al.*, 1994 and Febel *et al.*, 2002). The increase in blood cholesterol could be due to an obligatory response to help in transport of greater amounts of circulating fatty acids and total lipids (Sharma *et al.*, 1978; Magdus *et al.*, 1992).

6-4. Blood serum minerals:

Serum mineral (Table, 10) concentrations (Ca, P, Mg, Na, Cl & K) were not affected significantly (P<0.05) by the supplemented fat and all the parameters were around the normal figures in normal goats as reported by Castro *et al.* (1977).

7- Economical evaluation:

As shown in Table (11), feed cost of one Kg live body gain (LE) and economic feed efficiency were calculated. Results obtained in the present study indicated that addition of 4% palm oil to the ration of goats increase economic efficiency to 135.37% compared to the control ration.

The result obtained in this study showed that palm oil can be supplemented to the diets of goats at 4% without any adverse effect on the feed intake, digestion in rumen, nitrogen balance. Also this level had

no effect on the biochemical parameters, beside it have an economical value.

The production response to the supplemental fat depends upon how the increased energy is partitioned; ration, animal and environmental factors affect the partitioning of the energy, thus further experimental work is required in this subject.

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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	8.6	4.0	3.6	2.4	81.1	0.04	0.30	3.11
Soybean meal	91	46.2	2.6	7.2	6.8	37.2	0.35	0.71	3.15
Wheat bran	90	16.3	4.5	13.4	7.0	58.8	0.11	1.35	2.67
Wheat straw	90	3.5	0.8	38.0	17.2	40.2	0.20	0.07	1.60
Palm oil	100	---	100	---	---	---	---	---	8.80
Limestone	96	---	---	---	100	---	38	0.02	---
Monobasic sod.phosphate*	87	---	---	---	100	---	---	25.8	---

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

Table 2: Physical & chemical composition of the experimental diets.

Ingredients	Experimental diets			
	1 (control)	2 (2% fat)	3 (4% fat)	4 (6% fat)
Physical comp.:				
Corn, ground	45.00	34.00	27.50	19.00
Soybean meal	6.00	7.50	8.50	12.70
Wheat bran	10.00	10.00	10.00	---
Wheat straw	37.30	44.80	48.30	60.20
Palm oil	---	2.00	4.00	6.00
Limestone	1.00	1.00	1.00	0.90
Mono. sod.phosp	---	---	---	0.50
Common salt	0.50	0.50	0.50	0.50
Min.mixt.*	0.10	0.10	0.10	0.10
AD_3E**	0.10	0.10	0.10	0.10
Chemical comp.:				
Dry matter (%)	89.72	90.05	90.33	90.73
Organic matter (%)	89.81	88.68	88.17	86.11
Crude protein (%)	9.58	9.59	9.62	9.61
Ether extract (%)	2.71	4.37	6.16	7.57
Crude fiber (%)	17.56	20.12	21.29	24.47
NFE (%)	59.96	54.60	51.10	44.46
Ash (%)	10.19	11.32	11.83	13.89
Calcium (%)	0.51	0.52	0.53	0.51
Phosphorus (%)	0.34	0.32	0.31	0.30
ME (Mcal/kg DM)	2.46	2.47	2.52	2.48

* Mineral mixture: each 100g contains; 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 and 1mg Se (AGRICO-international company).

**AD_3E, each gram of AD_3E contains 20.000 IU vitamin A, 2000 IU vitamin D and 400 IU vitamin E (AGRICO-international company)

Table 3: Dry matter intake of the different experimental groups.

Groups	Dry matter intake	
	g/kg body weight	g/head/day
1 (control)	26.17±3.10 [a*]	649±9.22 [a]
2 (2% fat)	23.39±2.50 [b]	566±2.81 [b]
3 (4% fat)	22.54±2.15 [b]	541±4.64 [b]
4 (6% fat)	18.19±1.50 [c]	433±9.32 [c]

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

Table 4: Performance of the goats during the experimental period.

Items	Experimental groups			
	1 (control)	2 (2% fat)	3 (4% fat)	4 (6% fat)
Initial weight, kg	23±0.41	22.67±0.31	22.30±0.85	22.50±0.20
Final weight, kg	24.8±0.36	24.2±0.28	24.0±0.89	23.80±0.21
Total weight gain, kg	1.80±0.12	1.53±0.10	1.67±0.11	1.33±0.12
Average daily gain, g/h/d	51.43±3.5[a]	43.71±2.94[b]	47.71±3.37[b]	38.0±3.09[c]
Dry matter intake, g/h/d	649±9.22[a]	566±2.81[b]	541±4.64[b]	433±9.32[c]
Growth efficiency (%)	7.92±0.61	7.72±0.56	8.82±0.61	8.78±0.88
Feed conversion	12.62	12.95	11.34	11.39
Crude protein intake, g	62.17±0.88	54.28±0.27	52.04±0.45	41.61±0.90
Protein conversion efficiency	0.83±0.06	0.81±0.06	0.92±0.07	0.91±0.09
ME intake (Mcal/h/d)	1.60±0.02	1.40±0.01	1.36±0.01	1.07±0.02
Energetic efficiency	32.14±2.49	31.22±2.25	35.08±2.42	35.51±3.58

Growth efficiency (%)= Average daily gain / dry matter intake × 100
Protein conversion efficiency = Average daily gain / crude protein intake
Energetic efficiency = Average daily gain / metabolizable energy intake
Feed conversion ratio = Feed intake / weight gain (McDonald, 1995)
*Figures in the same row having the same superscripts are not significantly different ($P<0.05$)

Table 5: Amount and chemical composition of fecal matter of the different groups.

Items	Experimental groups			
	1 (control)	2 (2% fat)	3 (4% fat)	4 (6% fat)
DM excreted	225±5.40	213±10.27	205±10.21	187±3.12
Chemical composition:				
OM, %	82.07	81.39	79.73	77.56
CP, %	9.60	7.80	7.50	6.70
EE, %	2.30	2.65	2.95	3.71
CF, %	30.90	33.62	35.94	39.80
Ash , %	17.93	18.61	20.27	22.44
NFE, %	39.27	37.32	33.34	27.35
Ca, %	0.95	0.92	0.98	0.81
P, %	0.62	0.55	0.52	0.47

Table 6: Digestion coefficient (%) of nutrients for different experimental groups.

Items	Experimental groups			
	1 (control)	2 (2% fat)	3 (4% fat)	4 (6% fat)
Dry matter	65.3±0.85 [a]	62.33±1.64 [a]	62.10±1.73 [a]	56.82±0.34 [b]
Organic matter	68.3±0.77 [a]	65.43±1.5 [a]	66.73±1.56 [a]	61.10±0.30 [b]
Crude protein	65.24±0.85 [b]	69.4±1.33 [a]	70.5±1.34 [a]	69.9±0.23 [a]
Ether extract	71.5±2.24 [c]	76.1±0.99 [b]	81.8±0.83 [a]	83.9±0.17 [a]
Crude fiber	39.0±1.49 [a]	37.1±2.74 [a]	36.1±2.92 [a]	29.8±0.54 [b]
Nitrogen free extract	77.3±0.55 [a]	74.3±1.12 [a]	75.3±1.13 [a]	73.5±0.21 [a]
Calcium	35.3±1.56 [a]	33.3±2.91 [b]	30.0±3.2 [c]	31.3±0.55 [c]
Phosphorus	36.8±1.59 [a]	35.2±2.80 [a]	36.2±2.91 [a]	32.1±0.67 [b]

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

Table 7: Nitrogen utilization of goats fed on the experimental diets.

Items	Experimental groups			
	1 (control)	2 (2% fat)	3 (4% fat)	4 (6% fat)
Nitrogen intake (g/h/d)	9.95±0.14 [a]	8.68±0.04 [b]	8.32±0.07 [b]	6.65±0.14 [c]
Fecal nitrogen (g/h/d)	3.46±0.08 [a]	2.66±0.13 [b]	2.46±0.12 [b]	2.00±0.03 [c]
Digested nitrogen (g/h/d)	6.49±0.14 [a]	6.02±0.04 [b]	5.86±0.10 [b]	4.65±0.11 [c]
Urinary nitrogen (g/h/d)	2.92±0.10 [a]	2.24±0.04 [b]	1.73±0.05 [b]	1.16±0.09 [c]
Nitrogen balance (g/h/d)	3.57±0.22	3.78±0.13	4.13±0.06	3.49±0.03
N.B. % of intake	35.88±2.00 [c]	43.55±1.72 [b]	49.64±0.94 [a]	52.48±0.85 [a]
N.B. % of absorbed N	55.02±2.35 [c]	62.79±1.31 [b]	70.48±0.43 [a]	75.05±1.32 [a]

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

Table 8: Ruminal parameters of the different experimental groups.

Items	Experimental groups			
	1 (control)	2 (2% fat)	3 (4% fat)	4 (6% fat)
Total bacterial count (/ml)	5×10^9 $\pm 2.3 \times 10^{8\,a}$	1.3×10^7 $\pm 2.1 \times 10^{6\,b}$	1.6×10^6 $\pm 1.1 \times 10^{5\,c}$	1.4×10^5 $\pm 1.2 \times 10^{4\,d}$
VFA conc. (meq/100 ml R.L)	10.79± 0.05 [a]	9.10±0.25 [a]	8.61±0.03 [a]	7.45±0.10 [b]
Ammonia conc. (mg/100 ml R.L)	14.21±0.35 [a]	12.50±0.42 [b]	11.73±0.50 [b]	10.05±0.43 [c]

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

Table 9: Blood biochemical changes of the experimental groups.

Items	Experimental groups			
	1 (control)	2 (2% fat)	3 (4% fat)	4 (6% fat)
Total protein (g%)	6.5±0.07 a	6.6±0.05 [a]	6.5±0.02 [a]	6.2±0.01 [a]
Albumin (g%)	3.3±0.01 a	3.6±0.06 [a]	3.6±0.03 [a]	3.5±0.04 [a]
Globulin (g%)	3.4±0.12 a	3.0±0.05 [a]	2.9±0.08 [a]	2.7±0.01 [a]
Alb/glob ratio	0.97±0.01	1.20±0.04	1.24±0.03	1.30±0.05
Glucose (mg%)	55±1.08 a	52±1.10 [a]	53±1.30 [a]	56±1.50 [a]
Total lipids (mg%)	675.2±3.95 d	691.2±4.50 [c]	700.6±5.10 [b]	720.8±5.00 [a]
Triglyceride (mg%)	35.7±2.50 d	40.0±3.45 [c]	45.7±4.10 [b]	53.8±3.75 [a]
Total cholesterol (mg%)	105±4.53 d	110±3.25 [c]	120±5.25 [b]	130±7.10 [a]
Uric acid (mg%)	0.6±0.01 a	0.8±0.04 [a]	0.7±0.02 [a]	0.8±0.01 [a]
B.U.N (mg%)	16.3±0.20 a	16.5±0.15 [a]	15.5±0.10 [a]	16.4±0.20 [a]

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

Table 10: Blood serum minerals of the experimental animals.

Items	Experimental groups			
	1 (control)	2 (2% fat)	3 (4% fat)	4 (6% fat)
Calcium (mg%)	9.5±0.20	9.9±0.50	8.9±0.35	8.9±0.10
Phosphorus (mg%)	5.35±0.10	5.50±0.09	5.68±0.15	5.32±0.08
Magnesium (mg%)	2.45±0.02	2.44±0.05	2.50±0.03	2.40±0.01
Sodium (meq/L)	147±0.45	146±0.50	148±0.75	146±0.90
Chlorine (meq/L)	105±0.70	108±0.95	106±1.00	108±0.80
Potassium (meq/L)	5.3±0.07	5.4±0.01	5.6±0.05	5.5±0.02

Table 11: Economical comparison between control and most preferable ration.

Item	Control	4% fat
Feed consumption (g/h/d)	649	541
Feed costs (LE)	17.42	14.36
Price of body gain (LE)	27.0	25.05
Net revenue (LE)	9.58	10.69
Economic feed efficiency (%)	54.99	74.44
Relative economic feed efficiency	100	135.37

Fig .1. Dry matter intake of the different experimental groups

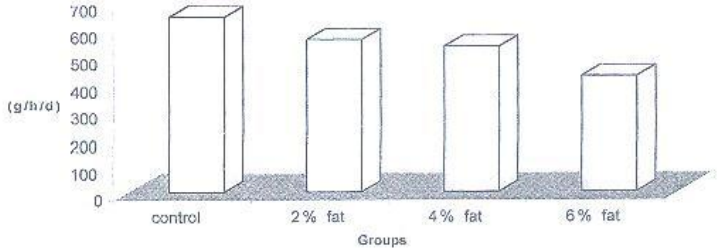

Fig .2. Digestibility of different nutrients in the experimental diets

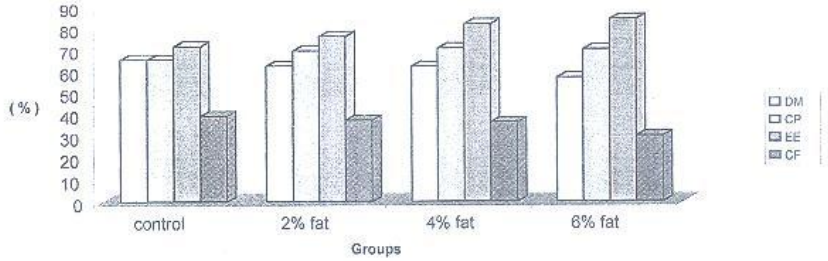

Fig .3. Nitrogen balance as % of absorbed N for different experimental groups