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EFFECT OF UNTREATED WHOLE COTTONSEEDS LEVEL ON PERFORMANCE, NUTRIENTS UTILIZATION AND REPRODUCTIVE RESPONSE OF RAMS

(With 8 Tables and 3 Figures)

By

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تأثير مستوي بذور القطن الغير معاملة علي كفاءة الآداء والاستفادة من العناصر الغذائية والقدرة التناسلية لذكور الاغنام

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في هذه التجربة تم استخدام عدد ١٢ من ذكور الأغنام الرحماني تراوحت أعمارها بين ١٢ و١٨ شهرا ومتوسط أوزانها ٣٩ كجم لدراسة أثر إضافة مستويات مختلفة من بذور القطن إلى علائقها علي أداء ومعامل هضم المواد الغذائية والاتزان النيتروجيني وبعض القياسات البيوكيميائية بالإضافة إلى صفات الكرش والكفاءة التناسلية خلال فترة التجربة التي استمرت ٩٠ يوما. قسمت الحيوانات إلى أربع مجموعات (٣ حيوانات/مجموعة). تمت تغذية المجموعة الأولي علي عليقة أساسية خالية من بذور القطن وأعتبرت عليقة مقارنة (العليقة الاولي) بينما أضيفت بذور القطن لكل من العلائق الثلاث الأخرى ٦% (العليقة الثانية)، ١٢% (العليقة الثالثة) و ١٨% (العليقة الرابعة). وقد خلصت التجربة إلى الأتي: عدم وجود أي اختلاف معنوي في كمية المادة الجافة المستهلكة بين مجموعات الحيوانات المختلفة علي الرغم من أن حيوانات المجموعتين المغذاة علي العليقة الضابطة والعليقة المحتواة علي ٦% من بذور قطن سجلت أعلي كمية استهلاك من المادة الجافة بينما نقص الاستهلاك مع العلائق المحتواة علي نسب أعلي من بذور القطن. معدلات الزيادة في وزن الجسم والتحويل الغذائي كانت أعلي معنويا في المجموعتين الاولي والثانية (الضابطة والمحتواة علي ٦% من بذور قطن) بينما انخفضت هذه المعدلات مع زيادة نسبة بذور القطن في العلائق. نقص معدلات هضم كل من المادة الجافة والعضوية والألياف ومستخلص خالي الازوت مع قلة المركبات الكلية المهضومة, بينما ارتفعت معدلات هضم كل من البروتين ومستخلص الأثير وزيادة معدل البروتين المهضوم في العلائق مع زيادة نسبة بذور القطن في العلائق المحتوية من ٦ إلى ١٨%. زيادة معنوية في معدل اختزان النيتروجين كنسبة من المستهلك أو الممتص مع

زيادة نسبة بذور القطن في علائق الحيوانات. عدم وجود أي تأثير معنوي لبذور القطن علي تركيز كل من البروتين الكلي والألبومين والجلوبيلين والجلوكوز في مصل دم الحيوانات المختبرة بينما زاد تركيز الكوليسترول مع النسبة الأعلى لبذور القطن (١٨%). عدم تأثر الحموضة الكرشية بإضافة بذور القطن بينما نقص العد البكتيري وتركيز الأحماض الطيارة في الكرش مع زيادة نسب بذور القطن في العلائق. وجود زيادة معنوية في قيم كل من المحيط الصفني وحجم الخصية المتوقع وتركيز هرمون التستوستيرون في مجموعة الحيوانات المغذاة علي العليقة المحتواة علي ٦% من بذور قطن مقارنة بالمجموعات الأخرى (١٢%, ١٨%), بينما لم يوجد أي اختلاف معنوي عن المجموعة الضابطة. من هذه الدراسة نستخلص أنه يمكن إضافة بذور القطن إلي علائق ذكور الأغنام بحد أقصي ٦% من مستوي العليقة الكلي دون أي تأثير ضار علي كفاءة الأداء ومعدل الاستفادة من العناصر الغذائية والقدرة التناسلية.

SUMMARY

A total number of 12 Rahmani rams ranging from 12 to 18 months age and averaging 39 kg weight were assigned to treatments to determine the possible associated effects of feeding whole cottonseed (WCS) on performance, digestion coefficient of ration nutrients, nitrogen balance, rumen characteristics and some blood metabolites. Reproductive response to treatments was also studied. The animals were randomly divided to 4 groups (3 rams /each). Treatments rations contained WCS as percentage of the total ration as 0 (control, I), 6 (ration II), 12 (ration III) and 18% (ration IV) whole cottonseed. Period of the experiment was continued for 90 days with total collection of feces and urine during the last 17 days of the experiment.

There was no significant differences in the total dry matter intake between the different experimental groups, but the maximum DM intake was recorded by rams fed the control and ration II (6% WCS) and gradually decreased as the level of WCS increased in the ration. Animals of these two groups (control and 6% WCS) had significant ($P<0.05$) increased average daily gain and better feed conversion, while there was a trend toward decrease as the levels of WCS increased in the rations from 12 to 18% with poor feed conversion. DM, OM, CF and NFE digestibilities as well as TDN values were decreased, on the contrary to CP, EE digestibilities and DCP which increased as the level of WCS increased from 6 to 18% in the rations. Nitrogen retention, as % of intake or absorbed, was significantly increased with increasing WCS in the rations of experimental animals. There were no significant effects of cottonseed addition on the blood serum concentrations of total protein, albumin, globulin and glucose, however, blood cholesterol increased

and Tyrrell and Moe, 1975). Effects of added ration fat on digestion and nutrient availability appear to be controversial, since WCS is relatively high in fat (about 20% of DM), it caused digestibility depression similar to free fat addition at the same level (Smith *et al.*, 1981 and Moore *et al.*, 1986). The effect of feeding cottonseed to bulls have varied, Smith et al. (1991) fed WCS to two year old bulls for 4 months without effect on testicular histology. However, Arshami and Ruttle (1988) found that feeding of WCS or cottonseed meal for 4 months had a detrimental effect on spermatogenic tissues and associated cells in yearling beef bulls. Moreover, Risco *et al.* (1992) reported that bulls fed cottonseed meal for 3 months had lower sperm counts by the fifth week, lowers sperm motility by the ninth week and increased sperm abnormalities.

The objectives of this study were to determine the effects of feeding whole cottonseed on the feed intake, digestibility, nitrogen balance, rumen characteristics, some blood metabolites and to evaluate the reproductive response of rams under local conditions.

MATERIALS and METHODS

1-Animals, feeding and management:

This study was carried out at the Animal Production Experimental Farm of the Faculty of Agriculture, Al-Azhar University, Assiut Branch. Twelve Rahmani rams (12-18 months in age and average range of weight 38-39 kg) were used in this study. The animals were allotted into four groups (3 animals each). Cottonseeds were added at the level of 0, 6, 12 and 18% for the rations of animal groups I, II, III and IV, respectively. All experimental rations were formulated to provide the recommended levels of TDN (72%) and crude protein (14.7%) according to NRC (1985) for sheep. The physical and chemical compositions of the ingredients and experimental rations are presented in Tables (1 and 2). The animals were fed twice daily. The amount of ration consumed or unconsumed (remained) was recorded at each meal and all animals had free access to clean water. Animals were weighed at the beginning and at the end of the experimental period, and feed intake was recorded throughout the experimental period.

2-Samples:

2-1. Ration ingredients, fecal matter and urine:

Ration ingredients 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 from the animals every month directly 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 was centrifuged at 3000 rpm for 20 minutes. A clear, non haemolysed sera were separated by pasteur-pipette and transferred into a clean, dry and sterile stoppered glass vials till biochemical analysis.

2-3.Ruminal juice samples: -

At the end of the experiment, 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 and Scott, 1994). In addition, samples of rumen contents 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.

3-Analytical methods:

For both feeds and feces, DM, CP, EE, CF and ash were determined according to AOAC (1990). Nitrogen free extract was calculated by difference. Nitrogen content of feces and urine samples were estimated also for calculation of nitrogen balance.

4-Estimations:

4-1.Ruminal acidity and total volatile fatty acids:

As soon as the ruminal fluid samples were obtained, the hydrogen ion concentration was estimated using pH meter. Total volatile fatty acids (TVFAs) was determined by gas-liquid chromatography (Intersmat, IGC 120 FB).

4-2. Nutrient digestibility:

Digestibility estimates were based on the nutrients as determined in the complete ration by the direct method at the end of the experiment.

4-3. Blood serum metabolites:

Total serum protein, albumin, globulin, glucose, total cholesterol, were determined using standard kits supplied by Bio-Merieux (Baines/France).

4-4. Hormonal assay:

Serum testosterone levels were determined by using commercial ELISA kits (Biosource, Co. Belgium). The minimal detection limit in the assay was 0.05 ng/ml and the intra-and interassay coefficients of variations were 8.5% and 7.3% respectively.

5-Testicular measurements:

Testicular measurements were performed every month. Scrotal circumference (SC) was determined by using a flexible measuring tap. The tests were gently forced into the scrotum by applying pressure with the hand above the head of the epididymis. The testicular length and width were measured by using Caliper. The predicted testicular volume (PTV) was calculated.

6-Statistical analysis:

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

RESULTS and DISCUSSION

1-Dry matter intake:

The effect of different levels of whole cottonseeds on consumption of DM are presented in Table (3). There was no significant differences in the total dry matter intake between the different four groups, but the maximum average intake was recorded by rams fed the control and ration II (1061.76 and 1050 g) and decreased as the level of WCS increased in the ration to reach 1000.57 and 996.66g for rams fed rations III and IV (12 and 18% WCS), respectively. The magnitude of depression as a percentage was 6.13% as WCS increased from 0 to 18%. The results seemed to be supported by the studies of Coppock *et al.* (1985), Luginbuhl et al. (2000) and Solaiman et al. (2002) who found a linear depression in DM eaten as WCS increased from 0% to 30% and 0 to 24% in the rations of dairy cows and goats, respectively and they attributed that to the toxicity from gossypol or to the high fat of the ration. On the other hand, Harvatine *et al.* (2002) stated that dry matter intake increased with increasing level of WCS in the rations of cows from 5 to 15%.

Intake of TDN/day was found to be significantly ($P<0.05$) high for the rams fed the control (744.4 g) and ration II (725.34 g) in comparison to the other two groups (650.3 and 641.22 g). On the contrary, DCP (g) was significantly ($P<0.05$) high for all the groups fed rations containing whole cottonseeds (103.79, 105.46 and 113.72g) compared to control one (96.3g). These results may be due to the decreased digestibility of fibre and NFE and increased digestibility of protein with increasing WCS levels in the rations of animals.

2-Animal performance:

The average live body weight, total weight gain, average daily gain and feed conversion are presented in Table (3) and illustrated in Figure (1). Feeding WCS did cause significant alterations in the average daily gain (ADG) and feed conversion. There was a trend toward decrease for both as the level of WCS increased (144.45, 133.33, 108.33 and 105.56 g) in the rations of four groups. As the level of WCS increased from 0 to 18% in the rations of rams, the depression in the average daily gain was 26.92%.

The best feed conversion ratio calculated as kg of DM or TDN required for each kg gain in live weight was obtained by both groups fed the control and ration II (7.35, 5.15 and 7.88, 5.44 kg, respectively) compared to other two groups fed the rations III and IV (9.24, 6.00 and 9.44, 6.07 kg, respectively). On the other hand, DCP conversion ratios were found to be 0.667, 0.778, 0.973 and 1.08 kg DCP for each kg gain in live weight for the four groups, respectively. Analysis of variance for this trait indicated that both the groups fed the control and ration II (6% WCS) had better TDN and DCP conversion ratios. Similar results were found by Zinn *et al* (1997) who reported that average daily gain and feed conversion decreased linearly with increasing WCS in the rations of cattle from 8 to 32%. Also Luginbuhl *et al.* (2000) found the same results with growing male goats when WCS increased from 0 -24% and they said that the detrimental effects of WCS on the animal performance of growing goats may be due to the possible negative effects of ration EE and NDF rather than gossypol.

3-Digestibility of the nutrients:

The values of digestibility are found in Table (4) and illustrated in Figure (2)

3-1.Dry matter and organic matter digestibility:

Significant differences ($P<0.05$) were found in the dry matter (DM) and organic matter (OM) digestibilities between the four different groups. A small decline in DM and OM digestibilities (76.09, 77.57% and 75.56, 77.67%, respectively) between the groups fed the control (0% WCS) and ration II (6% WCS) is evident, but still significantly higher than the animals fed the rations III and IV (12 and 18% WCS). DM and OM digestibilities were decreased by 16.76 and 16.31 percent units respectively as the level of WCS increased in the rations from 0 to 18%. Similar results were recorded by Moore *et al.* (1986) who found decreased DM and OM digestibilities with increasing level of WCS in the rations of steer to 30% and Liamadis *et al.* (1993) and Nagalakshni *et al.* (2003) by increasing the WCS from 0-30% in the ration of sheep and Coppock *et al.* (1985) and Zinn *et al.* (1997) in the ration of cattle from 0-30%. Also, Luginbuhl et al. (2000) obtained the same results with goats when the WCS raised from 0-24%. On the other hand, Smith *et al.* (1981) found that WCS had no effect on the dry matter digestibility in the lactating cows.

3-2.Crude protein digestibility:

Crude protein digestibility was significantly ($P<0.05$) increased with substitution of WCS for the basal ration to reach 15.97 percent units with high level of WCS (18%) than control one. This result is supported by the findings of Smith *et al.* (1981) and Coppock et al. (1985) with dairy cows; Liamadis *et al.* (1993) with sheep and Solaiman *et al.* (2002) with goats, who all reported linear increase in protein digestibility with increased WCS concentration in the rations. On the other hand, Zinn *et al.* (1997) and Luginbuhl *et al.* (2000) found no apparent relationship between WCS level and crude protein digestibility in cattle and goats.

3-3.Ether extract digestibility:

There was significant differences ($P<0.05$) between the four groups in the ether extract digestibility as the level of WCS increased in the rations. Factorially, EE digestibility was increased by 5.37 and 11.17 percent units with the higher levels of WCS (12 and 18%, respectively). The increase in the digestibility of EE with WCS substitution could be attributed to the dilution of the metabolic fecal fat with the high digestibility of ration fat. Similar results were found with dairy cows (Palmquist and Conrad, 1980; Smith *et al.*, 1981 and Coppock *et al.*, 1985), sheep (Liamadis *et al.*, 1993) and goats (Solaiman *et al.*, 2002).

3-4. Crude fiber and NFE digestibility:

Crude fiber and NFE digestibilities were nearly the same in both groups fed the control and ration II (61.38, 76.71% and 61.89, 78.53%, respectively) and decreased significantly (P<0.05) as the level of WCS increased in the rations (57.66, 59.05% respectively). Similar data were obtained with dairy cows (Palmquist and Jenkins, 1980); steers (Moore *et al.*, 1986); sheep (Liamadis *et al.*, 1993) and goats (Luginbuhl *et al.*, 2000 and Solaiman et al., 2002). On the other hand, Smith *et al.* (1981), Zinn *et al.* (1997) and Harvatine *et al.* (2002) found no significant effect on the digestibility of crude fiber or NFE by increasing the WCS level in cattle ration.

4-Nitrogen balance:

In contrast to the digestibility results, the absorbed nitrogen was significantly (P<0.05) increased as the level of WCS increased in the experimental rations (Table, 5). The same was recorded with nitrogen balance, as % of intake or absorbed. Similar results were found by Smith *et al.* (1981) and Liamadis *et al.* (1993) who reported that nitrogen retention was significantly increased with increasing cottonseed in the rations of cattle from 0 to 25% and from 0 to 30% for sheep. Also, Brosh *et al.* (1989) evaluated various levels of WCS for cattle and found that nitrogen retention was increased as WCS increased from 0 to 24% of the ration and the 12% represents the optimum.

5-Serum biochemical changes:

Blood serum concentrations of total protein, albumin, globulin and glucose between animals of each group during three times of collection (1st, 2nd and 3rd month) seemed to be not affected by WCS substitution (Table, 6). In contrast, increased concentration of blood cholesterol was obtained with rams fed the ration containing high level of WCS (18%). Similar results were found by Belibasakis and Tsirgogianni (1995) as they fed cows on rations containing 20% WCS, and no significant differences were observed in blood plasma concentrations of glucose, total protein but cholesterol concentration increased. In addition, Bernard and Calhoun, (1997) found that plasma glucose concentration was not affected when dairy cows fed different levels of WCS.

6-Rumen characteristics:

There was no significant differences in the pH of rumen between different experimental groups and the levels of WCS was not adversely affect the pH of rumen as shown in Table (7). Total bacterial counts of rumen were significantly (P<0.05) decreased as the levels of WCS increased in the rations and control group have 3.5×10^8, while the group fed on high level of WCS (18%) have 1.7×10^4. These agreed with that found by Nagalakshmi et al. (2003) who reported that feeding lambs with raw CSM amounting to 17.9% adversely affected ruminal microbial growth and utilization of nutrients. Zinn (1995) found that substitution of tapioca with 15% WCS in the rations of cattle decreased ruminal microbial growth. Volatile fatty acids concentration were decreased with increasing the level of WCS in the ration and the control group have 10.11 meq/100 ml rumen liquor, while the high level of WCS (18%) have 7.15. On the contrary, addition of supplemental fat from WCS had no significant effect on ruminal concentration of VFAs (Harrison *et al.*, 1995). Feeding polyunsaturated oils as part of a whole-oilseed ration has minimal effect on fermentation, probably because the oil is released slowly from the seed to ruminal fluid (Knapp *et al.*, 1991 and Depeters *et al.*, 1987).

7-Testicular measurements and testosterone concentration:

The obtained results are presented in table (8) and illustrated in Figure (3). It is clear from the present results that ration II (6% WCS) had a better effect on the SC and PTV compared to the other treatments (12 and 18% WCS). The values of SC and PTV were increased significantly ($P<0.05$) in the rams fed ration II (6% WCS) compared to the other rations (12 and 18% WCS), while there was no significant difference with the control one. At the end of experiment, the variation of PTV and SC mean values of the rams fed ration II (233.06 ± 10.75 c.c and 33.98±1.04 cm, respectively) were lower (non-significant) in comparison with the control one (243.88±20.63 c.c and 35.63 ± 1.62 cm, respectively). The variation of PTV and SC mean values between rams fed the rations containing 12% and 18% WCS and the control group differed significantly ($P<0.01$).

Serum concentrations of testosterone (ng/ml) were significantly affected by the levels of WCS (Figure,3). The serum levels of testosterone were increased significantly ($P<0.05$) in the rams fed ration II (6% WCS) and control one, while decreased as the level of WCS increased in rations III and IV (12 and 18% WCS). The testosterone levels were 3.05±0.39 ng/ml in the serum of rams fed the control ration compared to 2.72±0.09, 1.19±0.05 and 0.83±0.08 ng/ml in rams fed rations II, III and IV (6, 12 and 18% WCS), respectively.

The obtained results indicated that feeding of ration containing 6% WCS had no significant effect on the PTV, SC and testosterone concentrations. This is in agreement with the results of Cusack and Perry (1995) who found no significant differences between bulls fed on rations containing WCS or not in the scrotal circumferences. However, the findings of smith *et al.* (1991) indicated that, feeding of large amounts of free gossypol had no effect on testicular parameters. The variations in the results of previous gossypol feeding trials with ruminants might initially relate to the differences in the free gossypol content of the cottonseed (Arshami and Ruttle, 1988 and Risco *et al.*, 1992). Furthermore, ruminants are considered to be relatively tolerant to gossypol because of its binding in the rumen by the epsilon amino group of lysine (Reiser and Fu, 1962), calcium (Holmberg *et al.*, 1988), iron, sodium and potassium (Smith *et al*, 1991) and acetylamine (Singleton and Kratzer, 1973).

It could be concluded that the upper limit to whole cottonseed intake by the rams in this experiment was 6%. More research must be done to obtain the optimum level of inclusion without adverse effect on the performance, nutrient utilization and reproductive performance.

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Table (1): Chemical composition (%) of the ration ingredients

Items	DM	On DM basis						TDN
		CP	EE	CF	Ash	Ca	P	
Corn	88	9	4.2	3	2	0.02	0.30	87
SBOM	91	51	2	5	7	0.40	0.73	84
Wheat bran	89	17	4.8	11	7	0.13	1.30	70
Cottonseed	89	23	19	28	4	0.16	0.62	94
Wheat straw	91	3	1.5	43	8	0.16	0.05	44

Table (2): Physical & chemical composition (%) of the experimental rations

Ingredients	Experimental rations			
	I (control)	II (6% WCS)	III (12% WCS)	IV (18% WCS)
Physical comp.:				
Corn, ground	44.0	42.5	37.0	32.8
Soybean meal	14.0	15.0	13.0	11.8
Wheat bran	17.0	6.0	7.0	4.0
Wheat straw	23.0	28.5	29.0	31.4
Whole cottonseed	00.0	6.0	12.0	18.0
Limestone, ground	1.1	1.1	1.1	1.1
Common salt	0.5	0.5	0.5	0.5
Min.mixt.*	0.15	0.15	0.15	0.15
AD_3E**	0.25	0.25	0.25	0.25
Chemical comp.:				
Dry matter	89.49	89.64	89.76	87.75
Organic matter	93.77	93.42	93.22	93.26
Crude protein	14.70	14.74	14.70	14.70
Ether extract	3.30	3.95	4.87	5.70
Crude fiber	13.78	16.63	18.36	20.55
NFE	61.99	58.10	55.29	52.31
Ash	6.23	6.58	6.78	6.74
Calcium	0.50	0.50	0.50	0.50
Phosphorus	0.46	0.37	0.37	0.36
TDN	72.0	72.0	72.0	72.0

* 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 20000 IU vitamin A, 2000 IU vitamin D and 1 mg vitamin E (Rovigypt company).

Table (3): Performance of rams during the experimental period

Items	Experimental groups			
	I	II	III	IV
Int. body weight, kg	39.5±2.07	38.75±1.58	39.25±2.34	38.50±2.59
Fin. body weight, kg	52.5±2.51	50.75±1.17	49.0±2.11	48.0±2.29
Total weight gain, kg	13.0±0.58^{a*}	12.0±0.88^{a}	9.75±0.61^{b}	9.50±0.78^{b}
Av. daily gain, g	144.45±6.42^{a}	133.33±9.8^{a}	108.33±6.8^{b}	105.56±8.7^{b}
Growth rate, %	32.91	30.97	24.84	24.68
Av. daily feed intake:				
TDMI, g/head**	1061.76± 12.50^{a}	1050± 15.10^{a}	1000.57± 10.45^{a}	996.66± 8.65^{a}
TDN, g/head	744.4±20.15^{a}	725.34±21.10^{a}	650.30±18.20^{b}	641.22±15.75^{b}
DCP, g/head	96.30±2.80^{c}	103.79±3.10^{b}	105.46±4.01^{b}	113.72±3.95^{a}
Feed conversion ratio:				
Kg DM / Kg gain	7.35	7.88	9.24	9.44
Kg TDN / Kg gain	5.15	5.44	6.00	6.07
Kg DCP / Kg gain	0.667	0.778	0.973	1.08

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

** TDMI= Total dry matter intake, TDN=Total digestible nutrients, DCP= digestible crude protein

Table (4): Digestion coefficients (%) of the nutrients of the experimental rations

Nutrients	Experimental rations			
	I (control)	II (6% WCS)	III (12% WCS)	IV (18% WCS)
Dry matter	76.09±2.06^{a*}	75.56±2.12^{a}	63.11±0.47^{b}	59.33±0.86^{b}
Organic matter	77.57±2.02^{a}	77.67±1.91^{a}	64.83±0.38^{b}	61.26±0.81^{b}
Crude protein	61.67±0.40^{c}	70.31±0.39^{b}	71.70±0.99^{b}	77.64±1.75^{a}
Ether-extract	70.53±0.20^{b}	72.31±0.68^{b}	75.72±1.88^{b}	81.70±1.22^{a}
Crude fiber	61.38±0.56^{a}	61.89±0.46^{a}	57.58±2.63^{b}	57.66±1.31^{b}
Nitrogen-free extract	76.71±2.09^{a}	78.53±3.33^{a}	64.72±1.81^{b}	59.05±0.61^{c}

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

Table (5): Nitrogen utilization of the different experimental groups

Items	Experimental groups			
	I	II	III	IV
Nitrogen intake, g/h/d	24.97±0.34 [a]	23.63±0.30 [a]	23.53±0.40 [a]	23.44±0.35 [a]
Fecal nitrogen, g/h/d	7.06±0.40	5.65±0.58	4.59±0.50	2.88±0.45
Digested nitrogen, g/h/d	17.91±0.50	17.98±0.43	18.94±0.40	20.56±0.38
Urinary nitrogen, g/h/d	12.83±0.60	11.38±0.40	11.04±0.50	9.61±0.45
Nitrogen balance, g/h/d	5.08±0.30 [d]	6.60±0.32 [c]	7.90±0.40 [b]	10.95±0.25 [a]
N.B. % of intake**	20.34±1.50 [d]	27.93±1.35 [c]	33.57±1.48 [b]	46.71±1.30 [a]
N.B. % of absorbed N	28.36±1.35 [d]	36.70±1.28 [c]	41.71±1.20 [b]	53.26±1.25 [a]

*Figures in the same row having the same superscripts are not significantly different ($P<0.05$)
** N.B= Nitrogen balance

Table (6): Serum biochemical changes in the serum of the experimental groups

Items		Experimental groups			
		I	II	III	IV
Total protein (g/100ml)	1st month	7.43±0.04	6.94±0.05	6.84±0.23	7.20±0.28
	2nd month	7.70±0.11	7.33±0.06	7.10±0.23	7.40±0.22
	3rd month	7.57±0.05	7.70±0.07	7.89±0.21	7.83±0.19
	Mean±SE	7.57±0.08 [a]	7.32±0.16 [a]	7.28±0.22 [a]	7.48±0.13 [a]
Albumin (g/100ml)		3.30±0.04	3.28±0.07	3.32±0.22	3.63±0.06
		3.77±0.10	3.70±0.11	3.46±0.03	3.89±0.05
		3.67±0.06	3.97±0.14	3.91±0.20	3.69±0.18
	Mean±SE	3.58±0.10 [a]	3.65±0.14 [a]	3.56±0.13 [a]	3.74±0.06 [a]
Globulin (g/100ml)		4.13±0.09	3.66±0.02	3.52±0.14	3.57±0.22
		3.93±0.05	3.63±0.05	3.64±0.24	3.51±0.26
		3.90±0.07	3.73±0.08	3.98±0.01	4.14±0.13
	Mean±SE	3.99±0.05 [a]	3.67±0.02 [a]	3.71±0.10 [a]	3.74±0.14 [a]
Glucose (mg/100ml)		71±1.47	70.00±1.89	71±2.68	70.70±2.46
		63±0.71	61.33±1.31	55±3.54	55.00±2.04
		65±2.04	56.67±4.03	70±2.04	69.67±1.55
	Mean±SE	66.3±1.70 [a]	62.67±2.76 [a]	65.33±3.66 [a]	65.12±3.59 [a]
Total cholesterol (mg/100ml)		125.00±2.04	121.00±1.47	131.00±1.47	111.33±1.31
		123.33±1.18	120.00±1.03	141.66±3.12	161.66±3.12
		158.33±3.12	149.67±1.84	97.00±2.48	150.00±1.22
	Mean±SE	135.55±8.06 [a]	130.22±6.88 [b]	123.22±9.52 [b]	140.99±10.76 [a]

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

Table (7): Rumen characteristics of the animals of the different experimental groups

Items	Experimental groups			
	I	II	III	IV
pH of the rumen	5.98 ± 0.18^{a}	6.12 ± 0.02^{a}	5.59 ± 0.10^{a}	6.05 ± 0.12^{a}
Total bacterial count (/ml)	$3.5 \times 10^{8\,a}$ $\pm 1.3 \times 10^{7}$	$2.1 \times 10^{7\,a}$ $\pm 1.1 \times 10^{6}$	$1.5 \times 10^{6\,b}$ $\pm 1.0 \times 10^{5}$	$1.7 \times 10^{4\,c}$ $\pm 1.5 \times 10^{3}$
VFA conc. (meq/100 ml R.L)	10.11 ± 0.11^{a}	9.11 ± 0.49^{a}	8.22 ± 0.10^{b}	7.15 ± 0.29^{c}

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

Table (8): Effect of feeding whole cottonseed on the predicted testicular volume, scrotal circumference and levels of testosterone in rams

Items	Experimental groups			
	I	II	III	IV
PTV:**				
1st month	$187.38 \pm 24.57^{1,a}$	$183.32 \pm 22.31^{1,a}$	$160.45 \pm 21.66^{1,b}$	$137.58 \pm 18.53^{1,c}$
2nd month	$215.63 \pm 23.34^{2,a}$	$208.19 \pm 16.35^{2,a}$	$181.24 \pm 19.38^{1,b}$	$150.16 \pm 21.63^{1,c}$
3rd month	$243.88 \pm 20.63^{3,a}$	$233.06 \pm 10.75^{3,a}$	$201.33 \pm 15.61^{1,b}$	$171.46 \pm 08.53^{1,c}$
SC:				
1st month	$31.35 \pm 1.23^{1,a}$	$30.26 \pm 1.16^{1,a}$	$28.17 \pm 1.25^{1,b}$	$26.32 \pm 1.60^{1,c}$
2nd month	$33.54 \pm 2.52^{2,a}$	$32.15 \pm 0.76^{2,a}$	$29.94 \pm 1.06^{1,b}$	$28.11 \pm 1.25^{1,c}$
3rd month	$35.63 \pm 1.62^{3,a}$	$33.98 \pm 1.04^{3,a}$	$30.91 \pm 0.53^{1,b}$	$29.08 \pm 1.09^{1,c}$
Testosterone:				
1st month	$2.09 \pm 0.37^{1,a}$	$1.91 \pm 0.21^{1,a}$	$1.56 \pm 0.17^{1,b}$	$1.20 \pm 0.10^{1,c}$
2nd month	$2.57 \pm 0.31^{2,a}$	$2.29 \pm 0.19^{2,a}$	$1.39 \pm 0.06^{2,b}$	$0.98 \pm 0.11^{2,c}$
3rd month	$3.05 \pm 0.39^{3,a}$	$2.72 \pm 0.09^{3,a}$	$1.19 \pm 0.05^{2,b}$	$0.83 \pm 0.08^{2,c}$

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

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

LSD 5%: PTV = 22.8708, SC = 1.829, Testosterone = 0.3546.

LSD 1%: PTV = 26.2543, SC = 2.087, Testosterone = 0.4806.

** PTV= Predicted testicular volume, SC= Scrotal circumference

Fig.1. Total weight gain of the different experimental groups.

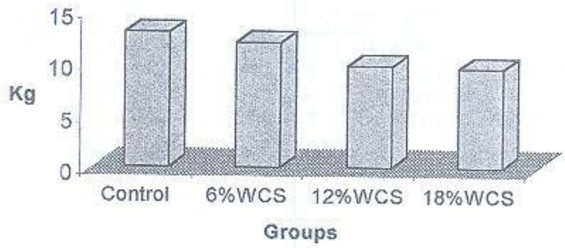

Fig.2 Digestibility of DM, CP & EE of the experimental diets

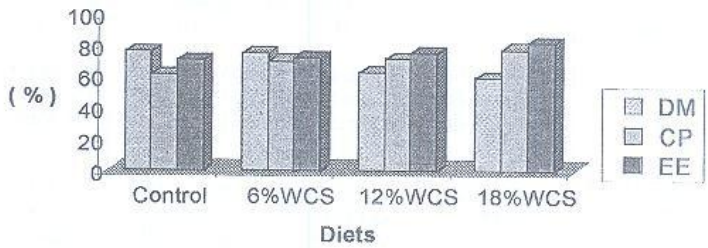

Fig.3. Effect of feeding WCS on testosterone concentrations of ram