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EFFECT OF SUPPLEMENTED DIETARY IODINE ON GROWTH PERFORMANCE AND THYROID GLAND ACTIVITY IN EGYPTIAN SAIDI LAMBS

(With 8 Tables, 5 Figures & 4 Plates)

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تأثيراضافة اليود لعلائق الحملان المصرية الصعيدية على الصفات الانتاجية ونشاط الغدة الدرقية

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اجريت هذه الدراسة على عدد ١٥ من الحملان الصعيدى عمر ١٠ شهور ومتوسط وزن ٣٦ كجم لمعرفة تاثير اضافة اليود على ا لصفات الانتاجية و نشاط الغدة الدرقية لكل حيوان. تم تقسيم الحيوانات المختبرة الى مجموعتين، مجموعة قياسية (الكنترول) وهذه غذيت بدون اضافة يوديد البوتاسيوم ومجموعة المعاملة وكانت تتغذى على ٢٦, ٥ مجم من يوديد البوتاسيوم لكل كجم عليقة . وقد تم تغذية الحملان فى المعاملتين على عليقة خشنة ومركزة حتى الشبع وتم تسجيل الغذاء المأكول يوميا كما تم وزن الجسم أسبوعيا، تم حساب الزيادة اليومية و معامل تحويل الغذاء (كجم معادل النشا/ كجم زيادة يومية) . تم قياس معدل التنفس وحرارة المستقيم والجلد كل أسبوعين وأخذت عينات الدم كل شهر وتم فصل السيرم لتقدير هرمون الثيروكسين وهرمون الغدة الدرقية ثلاثى اليود. تم ذبح أربعة حيوانات وأخذت الغدة الدرقية للدراسة الهستولوجية. أظهرت الدراسة أن أضافة اليود أدت الى زيادة معنوية فى الغذاء المأكول من العليقة الخشنة والمركزة والى تحسين معنوى فى معامل تحويل الغذاء (كجم معادل نشا /كجم فى الوزن والزيادة اليومية) ووزن الجسم الحى فى المجموعة المعاملة بيوديد البوتاسيوم مقارنة بالكنترول (الضابطة). اضافة اليود فى العليقة ادت الى زيادة معنوية فى معدل التنفس ودرجة حرارة المستقيم والجلد. ادت المعاملة بيوديد البوتاسيوم الى زيادة معنوية فى وزن الغدة الدرقية وعدد الخلايا الحويصلية لكل حويصلة و الحجم الغروى مقارنة بالكنترول ولكن ادت الى ونقص معنوى فى عدد الحويصلات ومتوسط ارتفاع الخلايا مقارنة بالكنترول. كما أدت المعاملة باليود الى زيادة غير معنوية تقدر بحوالي ٧% فى كل من تركيز هرمون الثيروكسين وهرمون الغدة الدرقية ثلاثى اليود.

SUMMARY

A total number of fifteen Saidi lambs, about 9 months of age with average 36.66 kg live body weight were conducted to assess of supplemented dietary iodine on growth performance and activity of thyroid gland. Animals were classified into two groups similar in body weight. A control group (A), 8 animals, received no potassium iodide (KI) supplement while the second group (B), 7 animals, received 5.26 KI supplement /Kg diet. Body weight was recorded weekly while feed intake was recorded daily. Daily gain and feed conversion, Kg Starch value/kg body gain also was calculated. Serum blood samples were taken monthly for measuring of T_3 and T_4 hormones. Immediately after slaughtering, thyroid glands were taken for histological study. Results revealed that supplementation of dietary iodine resulted in a significant increase of roughage ($P<0.05$) concentrate and total feed intake ($P<0.01$). Dietary iodine significantly ($P<0.01$) improved live body weight and feed conversion. Respiration rate and both rectal and skin temperatures increased ($P<0.01$) due to KI supplemented.Dietary iodine resulted in significant ($P<0.01$) increase of thyroid gland weight, number of follicular cells and colloid volume per follicles while the number of follicles per field and average cell height decreased ($P<0.01$) significantly. Thyroid hormones (T_3 and T_4) were increased by about 7% in iodine treated lambs compared with control.

***Key words:** Potassium iodine, growth, thyroid, Saidi lambs*

INTRODUCTION

Iodine is a very important trace elements to the animal functions (McDowell, 1992). The level of iodine in the diet affects the thyroid gland activity (Leung et al., 1980) and/or thyroid hormone releases (Parker and McCutcheon, 1989). The chief effects of thyroid hormones are stimulating the basic metabolic rate via the metabolism of protein, lipids and carbohydrates, consequently influence the function of most organs (Horst et al., 1989). Thyroid hormone are necessary for the normal body growth and development of young animals, particularly muscle growth to control protein metabolism (Baruah et al., 1993). Iodine content in soil and water of an area depending upon its location and its distance from the sea (Groppel et al., 1989). Upper Egypt and New Valley are so far from the Red sea and Mediterranean sea, so, animal's feed and water of these areas may be deficient in iodine. Adel (1995) reported that the water content of iodine was 0.0042-0.001 ppm and 0.0028-0.0042 ppm in El-Kharga and El-Dakhala, respectively. Iodine requirement of sheep is 0.01-0.8 ppm. in diets without manifesting goitrogenesis (Knights et al., 1979), the higher level, being indicated for pregnancy and lactation. The average requirement of sheep is about 0.5 ppm per animal of iodine daily (NRC, 1985). As far as in Assiut town, the present study showed also a deficiency of iodine content in both water and feed where iodine content in water was 0.0023 ppm, while in feed was 0.038ppm, 0.0401 ppm and 0.0297 ppm in Berseem, bean straw and concentrate mixture diets, respectively. Consequently, the objective of this study was to investigate the effect of supplemental dietary iodine on animal performance and structural changes of thyroid gland in sheep under Upper Egypt condition.

MATERIAL and METHODS

Animals and Management:

A total number of fifteen Saidi lambs about 9 months of age and averaging 36.66 kg body weight were divided into two treatment groups similar in body weight, 36.62 and 36.71 kg, respectively. A control group (A, 8 animals) receiving no potassium iodide (KI) supplement while a treated group (B, 7 animals) received 5.26 mg KI supplement /Kg diet as recommended by Knights et al., (1979). The animals were kept in individual pens during 33 weeks experimental period. The tested animals fed Egyptian clover (Berseem), bean straw and concentrate mixture ad libitum. The concentrate mixture was consisted of 40% wheat bran, 32% maize, 25% decorticated cotton seed meal, 2% limestone and 1% sodium chloride. Chemical composition of the concentrate mixture, berseem and bean straw are presented in Table 1.

Table 1: Chemical composition of concentrate mixture, berseem and bean straw

Item	**Concentrates**	**Berseem**	**Bean straw**
Crude protein	18.80	12.12	5.19
Crude fat	3.94	3.22	2.24
Crude fiber	6.74	32.42	46.98
Nitrogen free extract	59.70	39.24	36.97
Ash	10.82	12.91	8.62
Iodine, mg/kg	0.297	0.038	0.401

* Calculated on dry matter basis

Animals were individually fed at 8.00 a.m. daily. Water was offered three times daily at 8, 12 a.m. and 6 p.m. Live weight of animals was recorded weekly, and daily gain was calculated. Feed intake was recorded daily and feed conversion, kg Starch value/kg body gain was also calculated.

Respiration rate (breath/min.) was determined by counting the flank movements for one minute biweekly at 12.00-14.00 hr. After that, rectal temperature and skin temperature were tested using clinical thermometer and telethermometer, respectively.

Immediately after slaughtering, thyroid glands were removed, cleaned carefully of extraneous tissues and weighted, then dissected into small pieces and fixed in Bouin fluid prepared for histological examination. The samples were sectioned into slices of 5 µm thickness using rotary microtome. Sections were stained with periodic acid schiff (PAS) & haematoxylin (McManus, 1948). The follicular diameter was measured in 100 follicles of the peripheral and central lobules of each gland. These follicles were considered small, medium and large when its diameter were up to 39.9 u, 40 to 80 u, and more than 80 u, as described by Salem et al. (1986). The percentage of each size was calculated. The number of follicles was counted in 50 microscopic fields at magnification of 10x40. The height was measured and number of follicular cells was counted, per ten follicles from each size at both the peripheral and central lobules. The colloidal volume was calculated according to the following formula. $V=4/3kr^3$ Where k = constant 22/7, r = radius, calculated as

D+d/4 and D=the largest diameter of colloidal follicle, d = the smallest diameter of colloidal follicle. Blood sample were obtained from all animals at 10.00 hr every month to determine Thyroxine and triiodothyronine. Serum thyroxine (T4) and triiodothyronine (T3) concentrations were determined using enzyme-linked immunosorbent assay kits supplied by Randox (United Kingdom).

Statistic analysis:

Data were statistically analyzing using general linear model (GLM) procedure of SAS (1982). For growth performance, physiological parameter and thyroid hormones, the following model was used $Yijk=\mu+Ti+Pj+(TP)ij+Eijk$ Where; Tijk=The observation, μ= general mean, Ti=Effect due to iodine treatment, Pj=Effect due to period, Tpij = Effect due to interaction of treatment and period, Eijk=The errors related to individual observation.

For histological examinations; the following model was used, $Yij= \mu + Ti + Eij$ Where; Yij = the observation, μ= General mean, Ti=The effect due to iodine treatment, Eij =The errors related to individual observation.

RESULTS

Results are obtainted at Tables 1 to 8 and Fig. 1 to 5.

DISCUSSION

1. Effect of dietary iodine on growth performance.

1.1. *Feed intake:*

Roughage, concentrate mixture and total feed intake are shown in Table (2). Iodine-treated lambs had higher intake of roughage ($p<0.05$), concentrate mixture ($p<0.01$) and total feed ($p<0.01$) than those of control ones. The total feed intake increased by about 7% due to iodine treatment. This result may be due to a positive effect of dietary iodine on thyroid hormone secretion (Donald et al., 1993). High secretion of thyroid hormones increased feed intake (Blair and Forbes, 1974; Vander Tuig et al., 1979 and Zayed et al., 1997). Similarly, also dietary iodine stimulates feed intake in growing Holstein heifers (Fish and Swanson, 1982).

1.2. Body weight and daily gain.

Body weight and daily gain increased gradually during the experimental period. At the end of experimental period, average body weight of iodine treated-lambs was significantly ($p<0.01$) higher than that of control ones (Table 2 and Fig 1). Average daily gain of iodine treated lambs was significantly ($p<0.01$) higher in iodine treated lambs than that of controls (Table 2 and Fig. 2). High body weight and daily gain of iodine treated lambs may be attributed to higher feed intake (Table 2). In addition, in the present study iodine treated lambs had higher concentrations of thyroid hormones and thyroid weight than that of controls (Tables 4and7) as reported by Zayed et al. (1997) in sheep. Baruah et al. (1993) found that thyroxine and triiodothyronine concentrations were positively correlated with body weight of male and female kids. Growth hormone and thyroid hormones are necessary for the normal growth and development (Brown and Millard, 1983). High significant correlation ($p<0.01$) was obtained between the thyroid weight and live body weight of the steers (Lutingh, 1962). Also, higher body weight and daily gain were found in iodine treated Holstein heifers (Fish and Swanson, 1982).

1.3. Feed conversion:

Feed conversion (kg starch value/kg gain) of iodine treated lambs was lower ($p<0.01$) than that of controls (Table 2 and Fig 3). This means that iodine treated lambs were more efficient in feed utilization than that of control ones. This result may be due to the increase of concentrate mixture intake (Table 2 and Fig. 4). High concentrate intake resulted in high propionate concentration. Propionate is a major source of glucose (Riis, 1983). High blood glucose increased plasma insulin concentration (Hadley, 1984), and insulin increases both number and size of cells (Gardner and Kaye, 1991) and/or different body components (Kobeisy and Abd El-Ati, 1995). The end result is the increase of feed conversion. Similarly, Webster (1979) reported that feeding ruminants diets containing a high proportion of concentrates increases the efficiency of utilization of metabolizable energy for fattening. Similar results were obtained in calves fed milk replacer containing 0.57 and 50 ppm iodine as ethylene diamine dihydroiodide from 3 to 38 days of age (Jenkins and Hidiroglou, 1990).

2. Effect of dietary iodine on some physiological parameters.

2.1. Respiration rate, rectal and skin temperatures:

Average respiration rates and both rectal and skin temperatures values increased significantly ($p<0.01$) in iodine treated lambs (Table 3). These results may be due to dietary iodine which stimulates thyroid hormones secretion (Table 3 and Table 4) as found by Swanson (1972). The increase of thyroid hormones secretion is associated with the increase of oxygen consumption and body temperature. The thyroid hormones believed to stimulate oxygen utilization through its action on mitochondria (McDonald, 1980). In addition, high rectal temperature of iodine treated lambs may be related to a higher feed intake (Table 2). Similarly, Biance et al. (1968) and Ulberg (1971) found that rectal temperature was increased due to the increase of feed intake. In addition, Donald and Curtis (1980) found that dietary iodine as ethylene diamine dihydroiodide increased body temperature and respiration rate in cows.

3.Effect of dietary iodine on thyroid gland.

3.1.Thyroid weight:

The absolute thyroid weight (g) and relative to thyroid weight in mg to live body weight in Kg (mg/kg BW) are presented in table 4. Iodine treated lambs had higher thyroid weight ($p<0.01$) or proportional to live body weight ($p<0.05$) than that of controls. Dietary iodine supplementation increased thyroid weight and proportional to live body weight by about 46% and 34% respectively. The increase of thyroid weight may be due to the increase of body weight of iodine treated animals. Luting (1962) found highly significant correlation between the thyroid gland weight and body weight of the steers. The increase of thyroid gland weight in iodine treated lambs may be attributed to that iodine stimulates colloid formation and accumulation inside the thyroid follicles. These results are in agreement with those obtained in bull calves by Newton *et al.* (1974) and in heifers by Leung et al., (1980).

3.2. Histological examination:

The values of different quantitative parameters of the thyroid gland in control and iodine treated lambs are presented in tables 5 to 7. The general structure of the thyroid gland of control and iodine treated lambs are shown in plates 1 to 4. Diameter (μm) of thyroid follicles small, medium, and large ones of the peripheral and central lobules were larger in iodine treated lambs than those of controls, with exception of small central follicles, as they had nearly similar diameter (36.87 Vs 36.09) in control and in treated lambs respectively. The overall mean of the thyroid follicle diameter of iodine treated lambs was larger (65.14 µm) than that of controls (59.54 µm). Dietary iodine increased diameter of thyroid follicles by about 10% (Table 5). In the peripheral and central lobules, the percentages of the small-sized follicles (up to 39.9 µm) and medium-sized follicles (40-80 µm), central follicles only, were found to be higher in control lambs than that in iodine treated lambs, while the percentages of large follicles (more than 80 µm) was found to be higher in iodine treated lambs in both peripheral and central lobules (Table 6). Number of follicles per field, average cell height were significantly higher ($p<0.01$) in control group, whereas number of follicular cells and colloid volume per follicles were higher ($p<0.01$) in iodine treated lambs than those of control group (Table 7 and plates 1-4). Such results may be related to the accumulation of colloid in thyroid follicles of iodine treated lambs compared with that of controls (Mangkoewidjojo et al. 1980). Similarly, Aschbacher (1968) found that thyroid glands from lambs in the group receiving no iodine supplement had very few colloid-filled follicles and ,in many cases, the high columnar-type epithelial cells filled the entire follicles. On the other hand, the sections from group receiving KI were almost entirely composed of colloid-filled follicles lined with low-columnar or flat epithelial cells. Also, the histological variations between the control and potassium iodide treated Shami goats were in the form of moderate differences in the follicular size and cellular height (Yasear *et al.*, 1993).

3.3. Serum triiodothyronine (T3) and thyroxine (T4) hormones:

Iodine treated lambs had higher serum T3 and T4 concentrations than that of control. Dietary iodine increased both serum T3 and T4 concentrations by about 7% (Table 8 and Figure 5). This result is mainly due to, absorbed, trapped, oxidized and incorporated iodine into thyroglobulin in the form of iodinated amino acid in the thyroid gland. The further hydrolysis of thyroglobulin releases both of T3 and T4 which are responsible for the hormonal activities of the thyroid (Larvor, 1983). Additionally, supplementation with iodine increased the response of thyroid hormones to thyrotropin-releasing hormones (Wichtel *et al.*, 1996). In addition, iodine treated animals had higher feed intake than that of controls (Table 2). Morovat and Dauncey (1995) reported that increased level of feed intake resulted in increased thyroid hormones.

Similar results were obtained in cows treated with iodine (Rajan et al., 1991).

It could be concluded that the improvement of body weight, daily gain and feed conversion of iodine treated lambs were mainly due to the stimulation effect of iodine on thyroid gland and/or thyroid hormones (T_3 and T_4) release.

Table 2: Feed intake, growth performance and feed conversion as influenced by dietary iodine in lambs.

Item	Treatment [a]	
LSM±SE	Control	Iodine[b]
Feed intake, kg/d		
Roughages	0.37±0.002[e]	0.38± 0.002[f]
Concentrates	1.14±0.010[c]	1.23± 0.011[d]
Total Feed intake	1.52±0.011[c]	1.62±0.012[d]
Growth performance		
Initial body weight, kg	36.62±1.84	36.71±1.96
Final body weight, kg	57.25±1.84[c]	63.21±1.96[d]
Daily gain, g/day	89.16±2.18[c]	111.55 ±2.34[d]
Concentrate feed conversion, kg feed/kg gain	13.50±0.45[c]	11.20±0.45[d]
Total feed conversion, kg feed/kg gain	17.82±0.63[c]	14.65±0.63[d]

a, Values are least -square means (L.S.M.) ± standard error of L.S.M. (S.E.)
b, animals supplemented with 56 mg KI per head per week. c,d ($p< 0.01$); e,f ($p< 0.05$)

Table 3: Respiration rates (Breath/min) and skin and rectal temperatures (°C) as influenced by dietary iodine in lambs.

Item	Treatment [a]			
	Control	S.E	Iodine[b]	S.E.
Rectal temperature, °C	39.22	0.22 [c]	39.42	0.42 [d]
Skin temperature, °C	38.40	0.02 [c]	38.63	0.02 [d]
Respiration rate, Breath/min.	58.32	0.55 [c]	64.44	0.02 [d]

a, values are least -square means (L.S.M.) ± standard error of L.S.M. (S.E.)
b, animals supplemented with 56 mg KI per head per week. c,d ($p< 0.01$)

Table 4: Effect of supplemental dietary iodine on live body weight* (Kg) and thyroid gland weight (g) of lambs.

Item	Treatment [a]			
	Control	**S.E.**	**Iodine[b]**	**S.E.**
Live body weight	61.75	3.15	67.25	3.15
Actual thyroid weight (g)	1.85	0.16[c]	2.7	0.16[d]
Proportional thyroid weight to body weight (mg thyroid weight/Kg BW)	30.00	2.57[e]	40.34	2.57[f]

a, values are least -square means (L.S.M.) ± standard error of L.S.M. (S.E.)
b, animals supplemented with 56 mg KI per head per week
c,d ($p< 0.01$) e,f ($p< 0.05$) * After 2 hours feeding.

Table 5: Diameter (μm)of thyroid follicles as influenced by dietary iodine in lambs.

Item	Treatment [a]			
	Control	S.E.	Iodine[b]	S.E.
Peripheral follicles				
Small	32.43	0.78	34.22	0.78
Medium	51.14	2.30	57.06	2.30
Large	83.85	2.83[c]	95.77	2.83[d]
Central follicles				
Small	36.87	0.68	36.09	0.68
Medium	60.82	1.89	64.52	1.89
Large	92.15	4.96	103.19	4.96
Mean	59.54		65.14	

a, values are least -square means (L.S.M.) ± standard error of L.S.M. (S.E.)
b, animals supplemented with 56 mg KI per head per week.
c,d ($p< 0.01$)

Table 6: Percentages (%) of thyroid follicles as influenced by dietary iodine in lambs .

Item	Treatment [a]	
	Control	Iodine[b]
Periferal follicles		
Small	32.5	10.0
Medium	58.5	59.0
Large	9.0	31.0
Central follicles		
Small	6.0	4.0
Medium	71.0	44.0
Large	23.0	52.0

a, values are percentages (%) of thyroid follicles. b, animals supplemented with 56 mg KI per head per week.

Table 7: Number of follicles per-field, average cell height, number of follicular cells and colloid volume per follicles (μm^3) as influenced by dietary iodine in lambs.

Item	Treatment [a]			
	Control	**S.E.**	**Iodine[b]**	**S.E.**
Number of follicles per field	12.26	0.32 [c]	9.280	0.32 [d]
Average cell height	8.600	0.57 [c]	7.430	0.57 [d]
Number of folliular cells	19.03	0.46 [c]	20.60	0.46 [d]
Colloid volume per follicles (μm^3)	58945.71	6853.88	1421616.92	6853.88

a, values are least -square means (L.S.M.) ± standard error of L.S.M. (S.E.)
b, animals supplemented with 56 mg KI/head/week c,d ($p < 0.01$)

Table 8: Thyroxine (T_3) and triiodothyronine (T_4) concentrations (ng/dl) as influenced by dietary iodine in lambs.

Sampling Period	T_4 Treatment[a]			T_3 Treatment[a]		
LSM±SE	Control	Iodine[b]	S.E.	Control	Iodine[b]	S.E.
1	96.80	95.20	1.25	1.95	2.03	0.02
2	89.60	91.46	1.25	1.90	1.98	0.02
3	73.80	78.00	1.25	1.31	1.28	0.02
4	96.30	101.00	1.25	1.21	1.23	0.02
5	81.50	91.50	1.25	1.09	1.17	0.02
6	75.90	83.70	1.25	1.26	1.30	0.02
7	80.60	85.10	1.25	1.28	1.58	0.02
8	70.80[c]	80.93[d]	1.25	1.34	1.62	0.02
9	87.60	95.40	1.25	1.02	0.93	0.02
Overall mean	83.60	89.10	0.43	1.37	1.46	0.01

a, values are least -square means (L.S.M.) ± standard error of L.S.M. (S.E.)
b, animals supplemented with 56 mg KI per head per week. c,d ($p < 0.05$)

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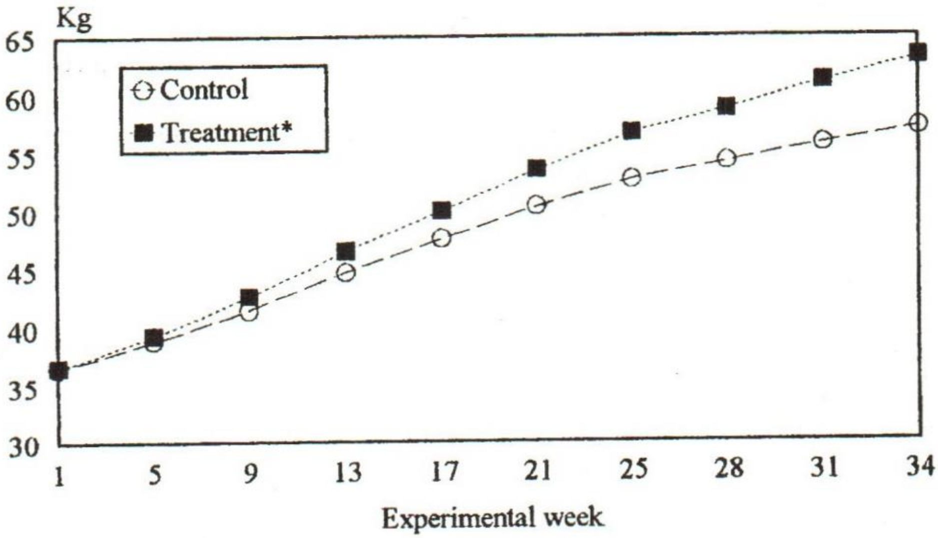

Fig 1. Body weight of experimental lambs as influenced by dietary iodine.

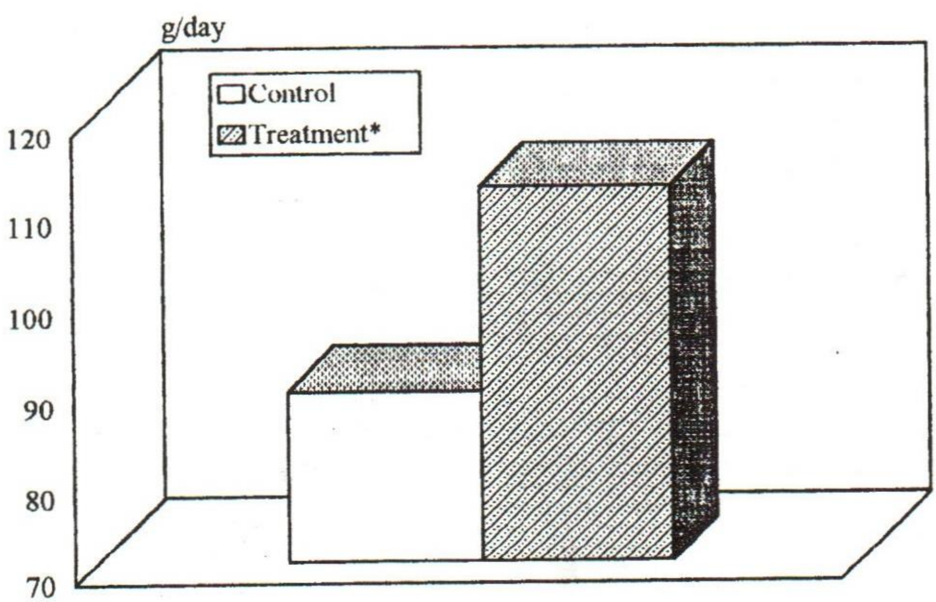

Fig 2. ᴄaily gain in lambs as influenced by dietary iodine.

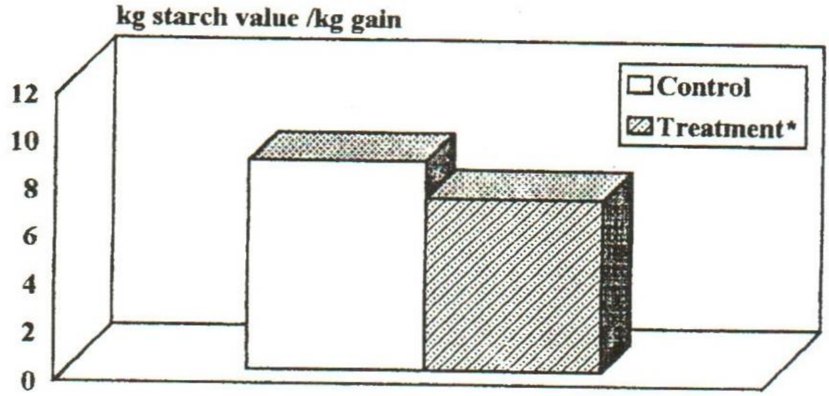

Fig 3. Feed conversion as influenced by dietary iodine in lambs.

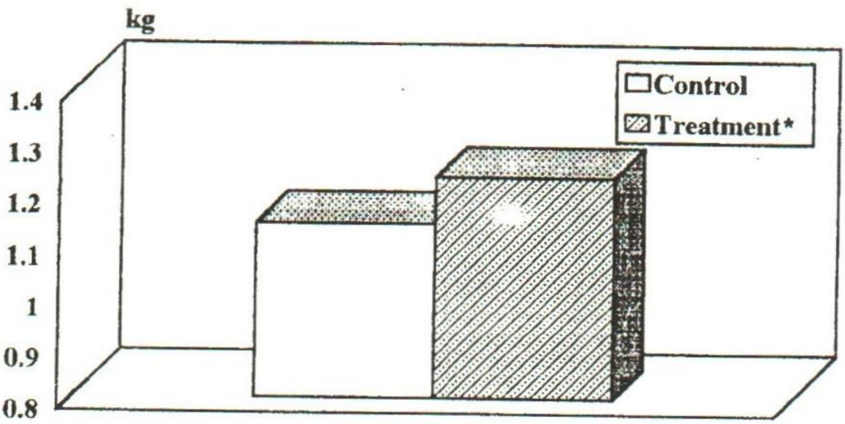

Fig 4. Concentrate intake as influenced by dietary iodine in lambs.

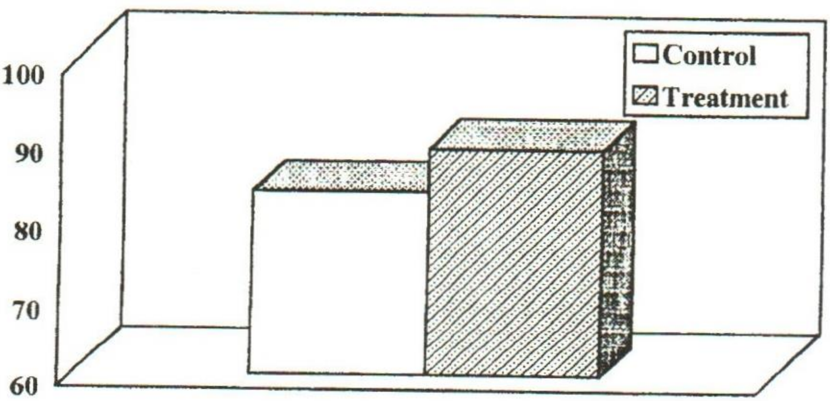

Fig 5. Serum thyroxine concentration (T4,ng/ml) as influenced by dietary iodine in lambs.

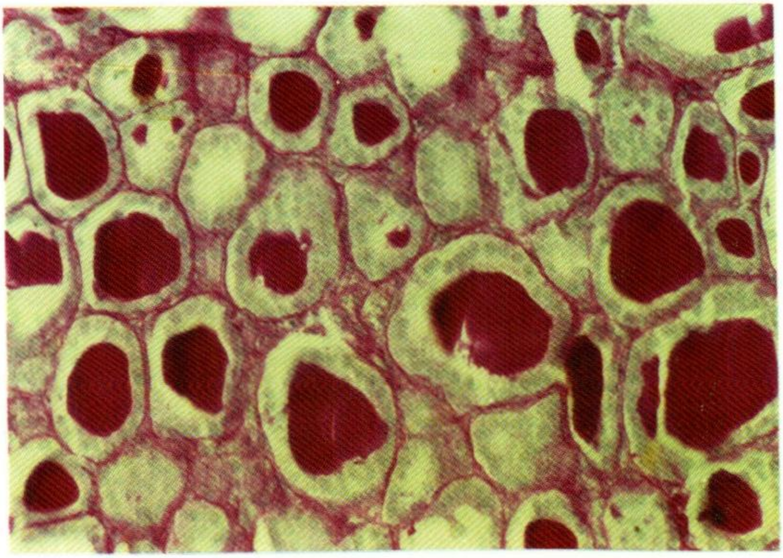

Plate 1. Thyroid gland of control lambs showing increased the average number of follicles per field and cell height of follicular cells lining the follicle (PAS & Hx. x400).

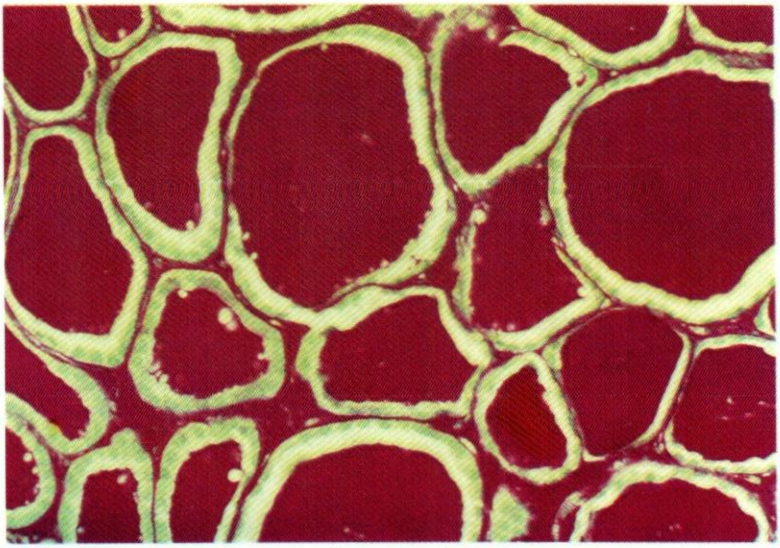

Plate 2. Thyroid gland showing decreased the average number of follicles per field and height of follicular cells lining the follicle in lambs treated with 56 mg KI/animal/ week (PAS & Hx. x400).

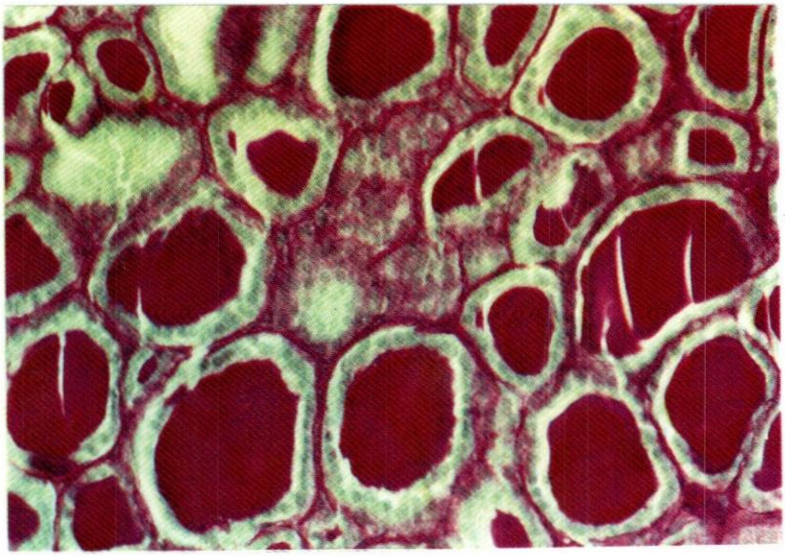

Plate 3. Thyroid gland of control lambs showing decreased the diameter of follicles, number of follicular cells and colloid volume per follicles (PAS & Hx. x400).

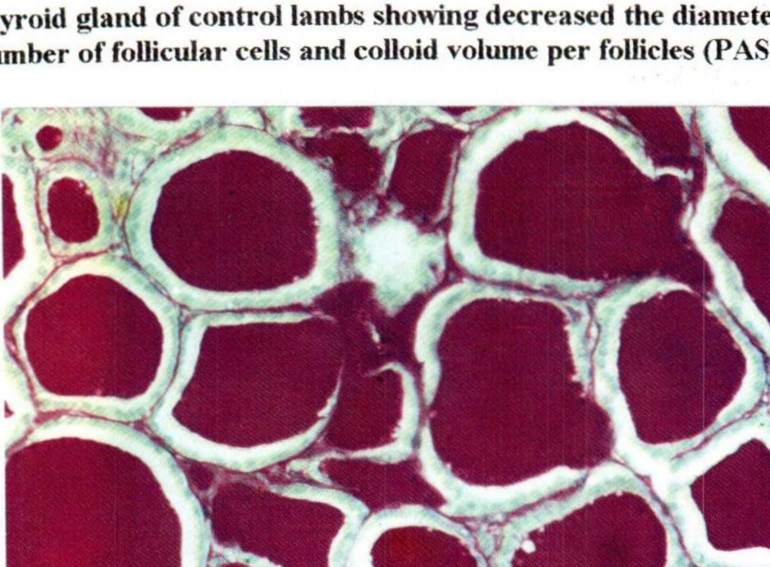

Plate 4. Thyroid gland showing increased the diameter of follicles, number of follicular cells and colloid volume per follicle in lambs treated with 56 mg KI/animal/week (PAS & Hx. x400).