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EFFECT OF SUPPLEMENTAL DIETARY IODINE ON THYROID HORMONE, SERUM CONSTITUENTS AND PERFORMANCE OF LACTATING WATER BUFFALOES

(With 4 Tables)

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تأثير اضافة اليود الى الغذاء على هرمون الدرقيه ومكونات مصل الدم وأداء الجاموس الحلاب

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استخدم في هذه الدراسه عشرة من الجاموس في منتصف مرحلة الحليب وقسمت الى مجموعتين طبقاً لوزن الجسم وانتاج اللبن . المجموعه الاولى ضابطه والثانيه اضيف الى عليقتها يود يد البوتاسيوم كمصدر لليود مرتين اسبوعياً على أساس ٢ر مليجرام يود/كجم من وزن الجسم يومياً . غذيت الحيوانات على عليقه مركزه وخشنه (٦٠ : ٤٠) لتغطية احتياجاتها الحافظه والانتاجيه خلال المرحله الاوليه (أسبوعين) والمرحله التجريبيه (سبعة أسابيع) ثم أخذت عينات لبن ودم في الأسبوع ٣ ، ٥ ، ٧ من الفتره التجريبيه وحللت العينات لبعض مكوناتها. في الأسبوع السابع من المعامله كان مستوى هرمون T3 أكثر ٤٠٪ (P< .02) وكذلك الجلسريدات الثلاثيه ٦٧٪ (P< .05). ولكن الكوليسترول أقل ٢٠٪ (P< .10) بالمقارنه بالمجموعه الضابطه . كان تركيز كل من البروتين والكلي والجلوبيولينات فى مصل الدم اقل ٨ر٥ ٪ ١٢٪ (P> .10). بالترتيب في الحيوانات المعامله باليود . أدت المعامله باليود الى زيادة قليله في تركيز كل من الجلوكوز واليوريا نيتروجين في مصل الدم في حين انخفض مستوى الالبيومين . في الأسبوع الثالث كان تركيز البيلوروبين اقل ٣٢ ٪ فى الحيوانات المعاملة ولكن لأتوجد فروق فى الأسبوع ٥ ، ٧ . كانت هناك زيادة طفيفة فى انتاج اللبن ونسبة الدهن واللبن المعدل الى ٧ ٪ دهن فى الحيوانات المعاملة باليود . وفى الأسبوع الخامس كان تركيز الجوامد الكلية فى اللبن اكثر معنوياً فى الحيوانات المعاملة ولاتوجد تأثيرات ضارة على صحة الحيوان نتيجة المعاملة باليود .

SUMMARY

Ten Egyptian Water buffaloes in mid-lactation were stratified by weight and milk production and randomly assigned into two treatment groups; a control group (A) receiving no iodine (I_2) supplement and an I_2-treated group (B) receiving supplemental dietary I_2 two times weekly on the basis of 0.2 mg I_2/kg body weight per day. All animals were fed a concentrate and roughage (60:40 DM basis) diet to cover their requirements for maintenance and production, during a 2 wk preliminary and 7 wk experimental periods. Milk and blood samples were obtained at wk 3, 5 and 7 of the experimental period and analyzed for certain constituents. At wk 7 of the experimental period, I_2-treated animals (B) had 40% more ($P<.02$) serum tri-iodothyronine (T_3) and 67% more ($P<.05$) triglycerides and 20% less ($P<.10$) cholesterol concentrations than controls (A). Serum total proteins and globulins levels were 8.5% and 12% lower ($P<.10$) in B group compared with A group, respectively. Serum glucose and urea nitrogen concentrations tended to be slightly higher, whereas albumin tended to be slightly lower in B group compared with A. Serum total bilirubin at wk 3 was 32% lower ($P<.05$) in B group compared with A and did not differ significantly ($P>.10$) at wk 5 and 7. Means of milk yield, fat% and 7% fat-corrected milk slightly increased and at wk 5 total solids% significantly increased due to I_2 treatment. No deleterious effects on animal health attributable to I_2 treatment were observed. (Key Words: Iodine, Thyroid hormone, blood, milk, buffaloes).

INTRODUCTION

The importance of iodine (I_2) to normal body functions has been known for a long time. dietary Iodine is almost completely absorbed in gastrointestinal tract (GIT) as the ion (I^-). Between 25% to 50% of the ingested iodide is trapped by the thyroid where it is concentrated and converted to other forms (COLLINS, 1975; HEMKEN, 1981). Its chief effects as a constituent of T_3 and T_4 hormones are stimulation of protein, fat and carbohydrate metabolism and growth and development of the body. It works very closely with growth hormone and insulin (KUTSKY, 1981). Excess I_2 is

excreted in the urine and in the milk during lactation (PYNE and PYNE, 1987). The daily requirement of I for cattle is about 10 mg/20 kg dry matter (DM) intake (NRC, 1978). WALLACE (1975) tentatively diagnosed I_2 toxicity in dairy herds receiving about 100 mg/head daily. Whereas CONVEY, et al. (1977) found a slight increase in milk yield in cows that received 164mg I_2/head daily compared with those receiving 16 mg. KOVAL'KOVA, et al. (1984) found that addition of 5 mg I_2 daily to the diet of the dairy cow had beneficial effects on milk production. Other studies (HEMKEN, et al. 1972) found no differences in milk yield of cows receiving either 6.8 or 68 mg I/head daily. Information on the I_2 requirements of lactating buffaloes and the effects of moderate excess intake is scarce. Therefore, the objective of this study was to determine whether or not supplemental dietary I_2 would affect performance and serum chemistry profile of lactating water buffaloes.

MATERIAL and METHODS

ANIMALS AND DIET.

In spring of 1991 (March to May) a study was carried out in the Animal Production Experimental Farm of the Faculty of Agriculture, Assiut University. Ten Egyptian water buffaloes averaging 495±27 kg body weight (BW) in mid-lactation were utilized in this study. The trial included 2 wk preliminary period and 7 wk experimental period. During these periods animals were individually fed the same diet (Table 1) to cover the requirements of lactation in water buffaloes as suggested by GHONEIM (1967) and calculated according to BW and milk production. Animals were given 40% roughage (rice straw) and 60% concentrate (DM basis) to cover their requirements. The concentrate diet was offered twice daily just before milking. Water was offered to the animals three times during the day and was available all night hours. At the end of the preliminary period, animals were divided into two treatment groups similar in BW and milk production, a control group (A) receiving no I_2 supplement and an I_2-treated group (B) receiving supplemental dietary I_2. The I_2 dose was calculated on the basis of 0.2 mg I_2/kg BW daily, but instead of dosing the animals daily, animals were given their respective doses only 2 times a week (i.e. weekly dose/2 on Sunday and again on Wednesday). Supplemental I_2 was given in the form of KI dissolved in about 50 ml of water and spread over the concentrate diet just before morning feeding.

Sampling and analytical methods:

Blood samples were obtained from all animals at wk 3, 5 and 7 of the experimental period. Samples were collected by jugular venipuncture 2 hr after morning feed, allowed to clot at room temperature and serum was then separated by centrifugation at 3000 rpm for 15 min. Serum was decanted into clean dry glass vials and stored at -20 C^{o} untill analyzed. Serum tri-iodothyronine (T_3) concentration was determined using a commercial enzyme immunoassay kit supplied by Immunotech Corp. (U.S.A). The within-assay coefficient of variation for serum T_3 was 12.7%. Serum albumin was determined using a kit supplied by bioMerieux (France), serum cholesterol was determined using a kit supplied by Medical Marketing Service (Germany) and serum total proteins, glucose, triglycerides, creatinine, urea nitrogen and bilirubin were determined using kits supplied by Diamond Diagnostics (Egypt).

Milk yield was recorded daily and individual representative milk samples from evening and morning milkings were taken at wk 3, 5 and 7 of the experimental period. Milk fat and total solids were tested as described by LING (1963). Buffaloes' fat corrected milk (BFCM) was calculated as described by RAAFAT and SALEH (1962) using the formula: BFCM (7% fat) = (.265 x milk yield) + (10.5 x fat yield).

Statistical analysis:

Serum T_3 and serum metabolites concentrations, milk yield, BFCM and milk total solids were analyzed by least-squares analysis of variance using the General Linear Model (GLM) procedure (SAS, 1987) for personal computers. The effects of treatment, animal within treatment, period (wk) and treatment x period interaction were determined in a split-plot analysis of variance appropriate for repeated measurements on the same animal (GILL and HAFS, 1971). Animal within treatment was used as the error term to test treatment effects across time periods. Whenever, a treatment x period interaction ($P<.10$) was detected. Means were compared within periods (STEEL and TORRIE, 1980).

RESULTS

Results are shown in tables 1, 2, 3 and 4.

Table 1. Composition of Concentrate and Roughage (Rice Straw) Fed to Control and Iodine-Treated Buffaloes.

	Rice Straw	Concentrates
	% of DM	
Crude protein	2.9	11.9
Crude fat	1.4	3.5
Crude fiber	31.0	13.0
Nitrogen free extract	48.7	63.4
Ash	16.0	8.2
Organic matter	84.0	91.8

Table 2. Serum Tri-iodothyronine (T_3), Glucose, Cholesterol and Triglycerides Concentrations in Water Buffaloes as Influenced by Supplemental Dietary Iodine.

Sampling Week	T_3, ng/dl			Glucose, mg/dl			Cholesterol, mg/dl			Triglycerides, mg/dl		
	Treatment[a,b]			Treatment[a,b]			Treatment[a,b]			Treatment[a,b]		
	A	B	S.E	A	B	S.E	A	B	S.E	A	B	S.E
3	186	189	12	39.2	46.9	2.9	85.8	80.0	8.02	19	18	4
5	210	195	12	46.5	48.4	2.9	80.0	90.8	8.02	26	19	4
7	144[c]	203[d]	12	58.1	55.5	2.9	88.8[e]	71.5[f]	8.02	18[g]	30[h]	4
Mean	180	196	16	47.9	50.3	2.8	84.9	80.8	8.70	21	22	3

[a]Values are least-squares means and S.E = standard error.

[b]Treatments: A = control; B = .2 mg I_2 as KI/kg body weight.

[c,d] (P<.02).

[e,f] (P<.10).

[g,h] (P<.05).

Table 3. Serum Total Protein, Albumin, Globulin, Urea Nitrogen and Total Bilirubin Concentrations in Water Buffaloes as Influenced by Supplemental Dietary Iodine.

Sampling Week	Total Protein, g/dl			Albumin, g/dl			Globulin, g/dl			Urea nitrogen, mg/dl			T. Bilirubin, mg/dl		
	Treatment[a,b]			Treatment[a,b]			Treatment[a,b]			Treatment[a,b]			Treatment[a,b]		
	A	B	S.E	A	B	S.E	A	B	S.E	A	B	S.E	A	B	S.E
3	7.8	6.7	0.6	3.21	2.91	0.29	4.64	3.83	0.46	29.6	35.5	3.0	0.50[e]	0.34[f]	0.05
5	8.3	7.7	0.6	3.04	3.03	0.29	5.26	4.62	0.46	28.9	28.1	3.0	0.26	0.27	0.05
7	8.4	8.0	0.6	3.28	3.24	0.29	5.14	4.79	0.46	29.3	29.4	3.0	0.26	0.32	0.05
Mean	8.2[c]	7.5[d]	0.5	3.18	3.06	0.16	5.01[c]	4.41[d]	0.46	29.3	31.0	2.3	0.34	0.31	0.03

[a]Values are least-squares means and S.E = standard error.

[b]Treatments: A = control; B = .2 mg I_2 as KI/kg body weight.

[c,d] (P<.10).

[e,f] (P<.05).

Table 4. Milk Yield, Total Solids(%), Fat% and Fat Corrected Milk (BFCM) in Water Buffaloes as Influenced by Supplemental Dietary Iodine.

Sampling Week	Milk Yield, Kg/head/d			Total Solids, (%)			Fat, (%)			BFCM 7%, kg/head/d		
	Treatment[a,b]			Treatment[a,b]			Treatment[a,b]			Treatment[a,b]		
	A	B	S.E	A	B	S.E	A	B	S.E	A	B	S.E
3	5.59	5.81	0.10	17.06	17.15	0.44	7.48	7.32	0.27	5.79	5.97	.14
5	5.34	5.41	0.10	17.21[c]	20.32[d]	0.44	7.37	7.68	0.27	5.52	5.74	.14
7	4.79	4.90	0.10	17.37	17.59	0.44	7.60	7.90	0.27	5.06	5.34	.14
Mean	5.24	5.37	0.39	17.21	18.35	0.54	7.48	7.63	0.32	5.47	5.68	.29

[a]Values are least-squares means and S.E = standard error.

[b]Treatments: A = control; B = .2 mg I_2 as KI/kg body weight.

[c,d] (P<.03).

[e,f] (P<.06).

DISCUSSION

Animal health:

The amount of I_2 required to support biosynthesis of thyroid hormone in the lactating dairy cow is less than 10 mg daily. I_2-supplemented buffaloes in the present experiment received more than 10 times the daily requirements suggested by NRC for dairy cows. However, they all were healthy and showed no signs of iodism. FISH and SWANSON (1983) found that daily intakes of up to 1.25 or 2.5 mg I_2/kg BW (about 50 to 100 ppm in diet DM) had minor effects on health and thyroid status of cows and their calves with no deleterious effects on lactation. In contrast, WALLACE (1975) observed hypertrophy of the thyroid in lactating dairy cows fed about 100 mg I_2/head per day (almost similar to the present I_2 treatment). These contradictory results suggest that the effect of I_2 upon health of animals might be subject to a complex of environmental conditions, besides the genetic factors, that may not exist in every dairy herd. For instance, HEMKEN (1981) reported some plants have substances that interfere with binding of I_2 by the thyroid gland. Nitrate also may reduce the uptake of I_2 by the thyroid. Increased K in the diet increases the loss of I_2 via the urine; high Ca diets and soybean protein are beleived to increase the need for I_2. Furthermore, lactating animals can tolerate excess I_2 in the diet because a large amount is secreted in the milk; the amount secreted depend on the level of intake, the form of I_2 consumed and stage of lactation or level of milk production.

Thyroid hormone and serum constituents.

Serum T_3 concentration in the present study averaged 188±5.0 ng/dl. In dairy cows, CONVEY, et al. (1978) reported T_3 concentration averaged 200±10 ng/dl and RONGE and BLUM (1989) reported an average of 1.37±.17 nmol/l (89.2 ng/dl) during lactation. Basal concentrations of T_3 reported by CONVEY, et al. (1978) is about 20 times greater than that of T_3; whereas that reported by RONGE and BLUM (1989) is about 47 times greater than that of T_3. But serum T_3 measured by radioimmunoassay (RIA) is total serum T_3 including protein bound and free T_3. KANEKO (1980) stated 99.95% of T_3 in the plasma is bound to protein and only .05% is present in the free state. Free T_3 and T_4 are the metabolically active hormones in the plasma and T_3 is 3–5 times more biologically active than T_4 (GRODSKY, 1983).

A treatment x period interaction ($P<.01$) was detected for serum T_3 concentration. When treatment means were separated within periods (Table 2)

significant differences occurred only at the end of the experimental period (wk 7). At that time I_2-treated animals had 40% more T_3 concentration than controls (203 vs 144 ng/dl). The increase in T_3 concentration in I_2-treated animals may be due to increasing the availability of I_2 to the thyroid to meet the increasing demand of thyroid hormone during lactation. JENKINS and HIDIROGLOU (1990) fed calves milk replacer containing 0.57, 10, 50 100 and 200 ppm I_2 in DM from 3 to 38 d of age and found that thyroid I_2 increased with every elevation in I_2 intake. However, CONVEY et al (1978) found that supplemental I_2 fed at about 200 to 400 times the requirement for 49 wk did not alter basal concentrations of TSH, T_4 or T_3. The big differences in dosage levels, besides species differences, between the two studies could explain these contradictory results.

Treatment did not affect ($P<.10$) serum glucose concentration (Table 2). Because glucose is essential for the synthesis of lactose, the uptake of glucose by the lactating mammary glands might be elevated in I_2-treated animals which in turn increased milk yield (Table 4) compared with controls. DAVIS et al. (1988a) found that T_4 injection (20 mg/d) for 4 d during successive 16-d experimental period increased mammary glucose uptake by 45%. Means of glucose concentration in the present study (Table 2) were within bovine range of values (40 to 80 mg/dl) reported by DUNCAN and PRASSE (1986).

The effect of treatment on cholesterol concentration differed ($P<.10$) with time periods (Table 2). Means at wk 3 and 5 fluctuated between the two treatments, but no significant differences were detected at either. At wk 7, the difference between the two treatments was noticeable ($P<.10$). Iodine-treated animals had 20% less cholesterol than controls. It is of interest to notice the reverse relationship between T_3 and cholesterol concentrations that occurred during the three sampling periods. Similarly, SHETAEWI et al. (1991) found that serum cholesterol concentration was 15% lower in lambs that received 80 mg KI/head/wk compared with unsupplemented controls. Serum cholesterol was previously used as an index of thyroid function because hypothyroidism is generally associated with an elevation in serum cholesterol (KANEKO, 1980 and DUNCAN & PRASSE, 1986). BERGERSEN (1979) suggested that thyroid hormones increase cholesterol synthesis and enhance the liver's ability to excrete cholesterol in the bile. But the effect on cholesterol excretion is greater than that on cholesterol synthesis; the net result is a decrease in plasma cholesterol concentration. However, serum cholesterol varies with a variety of factors unrelated to thyroid activity such as the nature of the diet, hepatic function and other factors (KANEKO, 1980).

Mean triglycerides concentration at wk 7 was 67% higher in I -treated animals compared with control ones (Table 2). It is possible that increased T_3 in I_2-treated animals resulted in increased lipid mobilization from fat tissue (GUYTON, 1981) which in turn increased serum triglycerides concentration. However, DAVIS, et al. (1988 b) stated that there was no detectable effect of T_4 injection on plasma triglycerides concentration.

Serum total proteins and globulins were lower (P<.10) and albumin tended to be lower in I_2-supplemented buffaloes compared with controls (Table 3). These findings could be due to increased secretion of thyroid hormone in I_2-treated animals which in turn increased rate of catabolism and mammary uptake of plasma proteins to be used in milk synthesis.

The effect of treatment on serum urea nitrogen was not significant; but I_2-treated buffaloes had slightly higher mean compared with controls (31.0 vs 29.3 mg/dl, respectively). This effect could be due to increased thyroid hormone in I_2-treated group which in turn result in a slight increase in protein catabolism. The decrease in serum total proteins, albumin and globulins in I_2-treated group is supportive to this view.

Serum total bilirubin concentration in both treatments (Table 3) fall within bovine range of values (.01-1.0 mg/dl) reported by DUNCAN and PRASSE (1986). A treatment x period interaction (P<.10) was detected for serum total bilirubin. Treatment means differed (P<.05) at wk 3 and were similar at wk 5 and 7. The reason that the control group had higher mean (.05 mg/dl) than I_2-treated animals (.34 mg/dl) just at wk 3 of the experimental period is unclear. It could be a transient increase due to increased heme degradation or decreased hepatic clearance of bilirubin.

Lactation performance

Milk yield, fat% and BFCM of I_2-treated animals showed slightly higher (P>.10) means compared with controls (Table 4). HEMKEN, et al. (1972) found no differences in milk yield of cows receiving either 6.8 or 68 mg I_2/head per day. Whereas, KOVAL'KOVA, et al. (1984) found that 5 mg KI supplement daily increased average milk yield from 8 to 9.8 kg and fat percent from 3.3 to 3.39% and persisted after the trial was terminated.

A treatment x period interaction (P<.05) was noted for total solids% (TS%). At wk 5 of the experimental period TS% was higher in I -treated buffaloes compared with controls (Table 4). The improvements in milk yield, fat% and Ts% in I_2-treated buffaloes'milk may be due to increased thyroid hormone synthesis. Thyroid hormone increases heart rate and mammary blood

flow, the proportion of cardiac output perfusing the udder is thus increases. These effects increase the amount of nutrients available for milk synthesis and therefore milk production should increase (DAVIS, et al. 1988 a). However, it should be noted that thyroid secretion rates and concentrations of T_3 and T_4 in serum are reduced in lactating animals compared with nonlactating ones, and as milk yield increases serum T and T decrease (TUCKER, 1985). LORSCHEIDER, et al. (1969) explained that TSH was elevated during lactation, but I_2 was insufficient to support the demand for thyroid hormone. This probably explains the importance of I_2 supplements to the lactating animal.

In the light of the present results, it is suggested that the intake of I_2 by lactating buffaloes under similar conditions can be raised by 10-fold above that recommended for dairy cows to achieve some increase in milk yield and butterfat with minimal additional costs and without any deleterious effects upon blood chemistry and health of animals. However, more studies are needed to confirm these results and to study long term effects of these dosage levels of iodine.

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