IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 11, Issue 3 Ver. I (March 2018), PP59-69
www.iosrjournals.org

Impact of dietary iodine supplementation on productive and reproductive performance of Maghrebian She-camels

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Abstract: *This study aimed to evaluate the effect of different levels of iodine supplementation during the period extended approximately twelve months (three months before and nine months after parturition) on immunity and performance of calves, and milk yield, milk composition, some blood parameters and reproductive performance of lactating she-camels. Twenty pregnant Maghrebian she-camels (3-5 parities) with live body weight ranging between 430 and 450 kg were used in this study. Animals were divided into four similar groups (5 in each). Animals in the 1st group (G1) were fed a control diet, while those in G2, G3 and G4 were fed the control diet supplemented with 0.5, 0.8 and 1.0 mg potassium iodide/kg DM intake /h/d, respectively. Daily (DMY) and total (TMY) milk yield, and lactation period length were recorded. Milk composition and milk iodine were determined. Concentration of immunoglobulin's was determined only in colostrum, Pre-partum and post-partum blood samples were taken for determination of total protein, globulin, glucose, total cholesterol (CHO), triglycerides, progesterone (P_4), estradiol-17ß (E_2) and iodine concentrations in blood plasma. Post-partum placenta expulsion, uterine involution, onset of 1st heat, calving interval, days open (DO), number of services/conception (NSC) and conception rate (CR) were recorded. After calving, live body weight (LBW) of calves was recorded and average daily and total gain was calculated. Results revealed that immunoglobulin concentration in colostrums was higher ($P<0.05$) in G4 as compared to G1, G2 and G3. She camels in G4 showed the highest ($P<0.05$) DMY and TMY (4.05 and 1422.20 kg) and the longest ($P<0.05$) lactation period (350.20 day). Milk in G4 showed lower ($P<0.05$) fat content (3.84%) as compared to G1 (4.63%), G2 (4.04%) and G3 (4.40%), highest ($P<0.05$) protein, lactose, ash, total solids, solid not-fat and iodine contents (4.11, 4.99, 0.92, 14.16, 10.02% and 129.09(μg/l) respectively. Concentration of T_3, E_2 and iodine during pre- and post-partum increased ($P<0.05$) in G4 as compared to the other groups. Placenta expulsion (157.20 minutes), uterine involution (30.60 day), onset of 1st heat (40.20 day), calving interval (456.00 day), DO (182.80 day) and NSC (2.60 serv.) decreased ($P<0.05$) in G4 as compared to other groups. The CR was 100% in G4, 80% in G3, 60% in G2 and 40% in G1. Daily and total gains of calves were higher ($P<0.05$) in G4 than in other groups. Placental weight was higher ($P<0.05$) in G4 as compared to other groups.*

Keywords: *She-camel, iodine, immunoglobulin, milk production, blood parameters, reproduction.*

Date of Submission:25 -02-2018 Date of acceptance: 10-03-2018

I. Introduction

In the Egyptian arid areas, one humped camel (*Camelus dromedarius*) considered one of the most numerous species of animal, which is an important livestock adapted to hot and arid environment more than any other domestic animals. Camel is contributed in the economical meat production and camel milk is one of the main components of the pastoral community's basic diet, which contributes up to 30% of the annual caloric intake, at the same time it is an important source of essential components and vitamin C (Farah *et al*., 1992). This region characterized by a lack of mineral elements which affected adversely on animal productivity and reproductive. Camel, like other animal must receive all essential nutrients despite the hostile environment (Ali and El-Sayed, 2015).

Trace minerals are essential nutrients required at levels generally less than 100 ppm in animal species affected by many factors including genetics, age, maintenance, growth, lactation, level of production and reproduction (Larson, 2005). Also, they have a wide range of activities and functions within the body such as hormone production, enzyme activity and some of physiological processes related to growth, reproduction and health (Paterson *et al.,* 1999). Trace minerals requirements may be increased to meet the various immune and metabolic stresses imposed during hard exercise (Snow *et al.,* 1992). During gestation adequate mineral status is also needed to provide the developing fetus with sufficient trace minerals for development or tissue accretion.

The storage of minerals in fetal tissue reflects fetal demands for growth and the ability of the dam to transfer minerals (Abdelrahman and Kincaid, 1993).

Iodine is needed in a very small percentage as dietary nutrients, which it is very important in camel nutritional programs for proper animal function. Iodine is a key component in the formation of thyroid hormones that contributes to brain development during fetal life and regulate basic metabolism, consumption of carbohydrates, proteins and fats and heat formation processes (Hoption, 2006) and to affect growth, development and the reproductive function (Georgievskii et *al*., 1990). Also, iodine deficiency disorder is the term now used, instead of goiter, to denote all the effects of iodine deficiency on growth and development. In camel, dietary deficiency of iodine or any disturbances in the absorption from the body tissues, leads to the appearance of different clinical symptoms include production performance such as, indirect influence of growth rate, milk production and feed consumption, and reproduction performance such as, irregular estrous cycles, poor conception rates, abortions, longer gestation periods and desorbed fetuses (Sanchez, 1995) and the birth of dead, weak or hairless calves. Moreover, pregnant animals are more susceptible to iodine deficiency than non-pregnant animals, which in turn increase the incidence of pre and postpartum reproductive disorders (Abdulwahhab, 2003). Animals suffer from iodine deficiency showed atrophy ovary and decrease milk production (Monget and Monniaux, 1995)

Therefore, supplementation of the pregnant animals with adequate trace minerals is essential as Hidiroglou and Knipfel (1981) stated the fetus relies entirely on the dam for a sufficient supply of trace minerals and other nutrients needed for growth and development. If trace mineral levels are sub-optimal in a transition period, the dam may not exhibit signs of clinical deficiency, but the transfer of these minerals to the calf may be affected. As the trace mineral status in the calf declines, immunity and enzyme functions are compromised first followed by a reduction in maximum growth and finally normal growth decreases prior to clinical deficiency (Wikse, 1992). Newborn calves depend not only on mineral reserves acquired from the dam but also on the mineral intake from colostrum. Calves are born with a naïve immune system and they need supplemental help via colostrum before they can mount an effective immune response on their own. Colostrum is is largely affected by mineral supplementation to the cow during the transition period. The use of supplemental trace minerals to the dam prior to parturition to increase the trace mineral content in fetal tissues and colostrum may help to enhance immunity in the calf.

Therefore, the present study aimed to evaluate the effect of iodine supplementation on birth weight of calves, colostrum's immunoglobulins, milk yield and composition, blood parameters and reproductive performance of Maghrebian she-camels.

II. Materials And Methods

This study was carried out in Center of Studies and Development of Camel Production, Marsa Matrouh Governorate, belonging to the Animal Production Research Institute, Agricultural Research Centre, Giza, Egypt.

Animals and feeding system:

Twenty Maghrebian she-camels (3-5 parities) with live body weight between 430 and 450 kg, at late pregnancy period (approximately three months) were divided randomly into four similar experimental groups (5 animals in each) according to live body weight and parity. The basal ration was consisted of concentrate feed mixture (CFM), berseem hay (BH) and rice straw (RS) given to camels in all groups without additives in the control treatment (G1), while those in G2, G3 and G4 were fed the basal ration supplemented with iodine at levels of 0.5, 0.8 and 1.0 mg sodium iodide per kg DM, respectively.

Iodine supplementation was add as a powder, so, the dose was well mixed with some of the ground concentrate feed mixture before feeding and all animals were individually fed a ration according to the recommendation of Animal Production Research Institute (Table 1), which cover both maintenance and milk production requirements. Feeds were offered to animals in all groups twice daily during the experimental period.

The camels were left for two weeks (as a preliminary period) on the same diet before receiving any supplementation. The experimental period lasted approximately one year (three months before the expected calving date and continued up to the 9^{th} month of lactation period.

All animals were housed in semi open pens until time of delivery then they were transferred to the maternity unit. Water was offered freely in water troughs except at the milking time.

After delivery all camels were allowed to nurse their calves for only one week postpartum (period of colostrums intake), thereafter the dams were transferred to the milking unit. Live body weight was recorded for dams at pre- and post-partum periods and for new born calves after calving until weaning , then daily and total gain of calves in each group were calculated.

Table (1): Chemical analysis (on DM basis) of different feed-stuffs in the basal ration of she-camels in all groups.

Nutrient	CFM	RS	BH
DM (%)	89.44	88.46	89.0
Chemical analysis (%):			
OM	92.43	82.24	87.7
CF	8.85	35.69	30.5
CP	12.24	2.53	11.30
EE	4.64	1.52	3.20
NFE	66.70	40.50	37.70
Ash	7.57	19.76	12.3

CFM: Concentrate feed mixture. BH: Berseem hay. RS: Rice straw.

Colostrum analysis:

Colostrums samples were collected within one hour of parturition (first milking) from each dam at the 1^{st}, 2^{nd} and 3^{rd} day postpartum for immunoglobulin studies. Determination of immunoglobulins (IgA, IgM and IgG) in colostrum was applied by Bovine radial immune-diffusion (RID) kit according to the procedure outlined by the manufacturer (Ltd, Birmingham, UK). The principle of the technique was derived from the work of Mancini *et al*. (1965) and Fahey and McKelvey (1965).

Milking and milk samples:

All camels were hand milked twice a day at 7a.m and 5 p.m. Milk yield was measured after the born calves were allowed to suckle colostrum from their dams for the first seven days. After each milking, milk was weighed on limited day for each week and then monthly milk yield was calculated for the lactation period.

Milk composition:

Milk samples (30 ml) were collected from each camel at milking time in clean glass bottles. Whole milk samples were stored frozen at−20◦C without adding preservatives then the samples were heated to 40°C in a water bath and held at this temperature for 15 min for detection of protein, fat, lactose, and ash using Lactoscan (Ultasonic Milk Analyzer, Bulgaria). The iodine content of milk and blood plasma was determined by the colorimetric method at Regional Center for Food and Feed, Agricultural Research Center, Giza, Egypt, according to the method of Sandell and Kolthoff (1937) and modified by Bobek and Kołczak (1960).

Blood samples:

Blood samples were collected from the jagular vein into test tubes containing heparin at 6.00 am then blood plasma was carefully separated after centrifugation at 4000 rpm for 20 minutes and stored at -20 ^{o}C) until analysis for the different blood parameters. Concentration of glucose (Trinder, 1969), total proteins (Armstrong and Carr, 1964), albumin (Alb) (Drupt, 1974), cholesterol (Kostner *et al.*, 1979) and triglycerides (Schalm *et al.*, 1975) was determined in blood plasma. Direct radioimmunoassay technique was performed for determination of progesterone, (P_4) and estradiol-17β (E_2), triiodothyronine (T_3) and thyroxin (T_4) hormones in representative plasma samples. Globulin concentration was also calculated by subtracting. Kits of Diagnostic Products Corporation, (DCP) Los Angles, USA with ready antibody coated tubes were used according to the procedure outlined by the manufacturer.

Reproductive measurements of she-camels:

Placenta expulsion (min), uterine involution (day), onset of 1^{ST} heat (day), calving interval (day), days open, number of services pre conception and conception rate were determined during post-partum period. Also, fetal fluid and placental weight were recorded at calving.

Statistical analysis:

The obtained data were statistically analyzed by complete design (one way) to study the effect of dietary iodine supplementation using SAS (2002) according to the following model:

$$Y_{ij} = \mu + A_i + e_{ij}$$

Where: Y_{ij}= observed values, μ= overall mean, Ai= experimental group) and e_{ij}= Random error. The detected significant differences among the experimental groups were tested using Multiple Range Test according to Duncan (1955).

III. Results And Discussion

Concentration of immunoglobulins in colostrum:

Table (1) showed the concentration immunoglobulin's in colostrum, which a descending trend was observed with sequence sampling days after parturition in all groups. Treated groups were showed higher values for IgA, IgM and IgG compared to control group. Also, treated group (G_4) was higher values in all immunoglobulin fractions than that the other groups (G_1, G_2 and G_3) respectively.

The immune status of the newborn calves is dependent upon the passage of immunoglobulin's from dams to the calves through the ingestion of colostrum and its subsequent absorption from small intestine Northeim *et al*. (1985). Also, Guyot *et al.* (2011) showed that iodine is transferred from the dam to the calf through placenta transmission rather than colostrum transfer.

Table (2): Immunoglobulins concentration (mg/ml) in colostrum of lactating she-camels as affected by iodine supplementation in different experimental groups.

Immunoglobulin fraction	Sampling day*	G1 (control)	G2 (0.5 mg/kg DM)	G3 (0.8 mg/kg DM)	G4 (1.0 mg/kg DM)
IgA	1st	3.40±0.35[b]	4.50±0.49[a]	4.62±0.19[a]	5.04±0.32[a]
	2nd	3.40±0.30	3.94±0.37	4.08±0.48	4.38±0.47
	3rd	2.60±0.41	2.98±0.46	3.34±0.61	3.74±0.37
IgM	1st	4.64±0.51	5.34±0.64	5.46±0.58	5.44±0.23
	2nd	4.12±0.45	4.88±0.45	4.90±0.33	5.68±0.43
	3rd	3.72±0.60	3.92±0.56	3.94±0.24	4.60±0.32
IgG	1st	35.0±0.89[c]	44.4±0.75[b]	47.0±1.34[b]	51.6±0.75[a]
	2nd	33.8±0.92[d]	41.4±1.08[c]	44.6±1.12[b]	48.8±0.92[a]
	3rd	30.0±0.45[c]	39.6±1.12[b]	42.6±1.12[a]	44.4±1.12[a]

Means in the same row with different superscripts are significantly different at P<0.05.
*** After parturition.**

The results are in agreement with those obtained by Zeedan *et al.* (2010 and 2012), who reported that using iodine supplementation increased concentration of all immunoglobulin fractions in colostrum of buffaloes. Nocek *et al*. (1984) reveled to the relation between IgG and pre-weaning growth, which, consumption of colostrum is essential to protected and provide calves with the antibodies and other proteins. The consumed amount of immunoglobulins determines amount of passive immunity and resistance to disease. Also, calves consume insufficient amounts of IgG from colostrum within the first 24 hours of life were much more susceptible to developing disease and possibly dying. Quigley (2005) mentioned to a major reason that pre-weaning mortality is higher than optimum is due to inadequate IgG intake. Mavi and Bahga (2005) found that a high immunoglobulin-G concentration was observed in calves fed ration supplemented with iodine. Gasanov (1991) found that supplemented potassium iodide to buffaloes had decreased calving problems, increased colostral density, and blood immunoglobulin concentrations. Adding that buffaloes were deficient in iodine was suffering in immunity.

The results for IgG concentration in the current study disagreement than those obtained by Salama *et al.* (1997) in buffalo calves, who observed that IgG contents in colostrum at the first 72 hr after calving were (16.4 and 10.9 mg/ml) in premiparous and pluriparous buffaloes, respectively. Generally, the amount of IgG in dam's colostrum depended mainly upon pre-partum administration of immunopotentiators, and in calves depended mainly upon consumption of colostrum directly after parturition. Also, iodine supplementation may be improved the thyroid function led to increase concentrations of immunoglobulin in colostrum**.**

Milk production:

Milk yield:

Average monthly milk yield at each month or as overall mean of nine month as a lactation period was significantly (P<0.05) higher in G3 and G4 as compared to G1 and G2, being highest in G4 and the lowest in G1. Average daily milk yield during the whole lactation months was significantly (P<0.05) higher in G4 than in other groups. However, total milk yield was associated with lactation period being significantly (P<0.05) higher in treatment groups than in control one (Table 3).

These results indicated that all iodine supplementations showed improvement in milk yield by 10.93, 12.73 and 14.22% in G2, G3 and G4 as compared to unsupplemented group, respectively.

In agreement with this results, Vereshchak *et al.* (2012) found marked increase in cow milk production due to the supplementing the diets with deficiency in the ration. Several authors came to the same results (Allam *et al*., 2003; Zeedan *et al.*, 2010 and 2012), who found that dietary iodine supplementation of lactating buffaloes and Friesian cows significantly increased milk production by about 10-18% as compared to control group. Borucki castro *et al.* (2012) found that iodine at levels 0.3, 0.6 and 0.9 mg I/kg DM increased yield of milk.

Table (3): Monthly, daily and total milk yield and lactation period of lactating she-camels as affected by iodine supplementation in different experimental groups.

Lactation month	Control group	Treatment group		
	G1	G2	G3	G4
1st	90.93±1.70[b]	105.34±3.97[b]	129.47±10.11[a]	140.46±10.26[a]
2nd	102.02±2.03[c]	119.29±5.67[bc]	139.90±8.45[ab]	151.12±9.22[a]

3rd	121.62±2.58[c]	138.79±4.98[bc]	158.00±7.33[ab]	177.44±9.56[a]
4th	118.26±2.52[c]	133.30±4.18[bc]	149.72±5.01[b]	170.07±9.49[a]
5th	113.08±2.87[c]	127.23±2.59[bc]	146.14±8.36[b]	166.85±8.87[a]
6th	109.80±4.18[c]	121.27±2.73[bc]	140.28±7.58[b]	160.04±9.17[a]
7th	105.42±2.50[b]	117.50±3.23[b]	137.55±8.41[a]	155.25±8.25[a]
8th	102.88±2.26[c]	119.45±6.00[bc]	138.86±6.09[ab]	153.74±9.75[a]
9th	93.52±2.61[b]	112.04±5.29[b]	133.75±8.63[a]	147.23±9.53[a]
Overall mean	106.40±2.07[b]	121.58±4.08[b]	141.52±7.06[a]	158.02±8.95[a]
Daily milk yield (kg)	3.67±0.12[b]	3.69±0.02[b]	3.89±0.10[ab]	4.05±0.12[a]
Total milk yield (kg)	957.54±18.63[c]	1094.21±36.73[b]	1273.66±63.53[b]	1422.20± 80.58[a]
Lactation period (day)	261.80±5.02[c]	296.40±8.18[b]	327.40±9.68[a]	350.20±12.85[a]

Means in the same row with different superscripts are significantly different at P<0.05.

Increasing milk yield in treated groups may be due increase level of thyroid hormones (T_3 and T_4). Also, Hoption (2006), Lawrence and Fowler (1997) and Georgievskii *et al.* (1990) mentioned that iodine has important role in function of most organs, several metabolic processes including protein, fat, carbohydrate, vitamin, mineral metabolism and synthesis of enzymes which affect intracellular processes of oxidation, oxidative phosphorylation and protein synthesis controlled by thyroid hormones. The present results indicated improvement in milk production by increasing level of iodine. Similarly, Gasanova (1985) found that increasing levels of iodine supplemented to ration improved feed utilization for milk production. Meanwhile, Norouzian *et al.* (2009) found insignificant effect of iodine treatment on milk yield of cows.

Milk composition:

Results presented in (Table 4) showed that dietary iodine supplementation at the lowest (G2) or the highest (G4) level showed significantly (P<0.05) marked reduction in fat content as well as pronounced increase in lactose, ash and solid not-fat contents in camel milk as compared to unsupplemented diets. Protein content significantly (P<0.05) increased by the highest level of iodine in G4. However, milk composition was not affected significantly by iodine at a moderate level (G3). As expected, level of milk iodine significantly (P<0.05) increased by increasing dietary supplementation of iodine.

It is of interest to note that only fat content showed negative relationship with milk yield, while protein, lactose, ash and solid not-fat contents showed positive relationships with milk yield in all experimental groups. In agreement with these results, Vereshchak *et al.* (2012) found an increase of milk contents due to the supplementing iodine deficiency in the ration in cows. Angelow *et al*. (1993) found that milk fat and protein were significantly higher in iodine supplemented group than in control one.

Table (4): Effect of iodine supplementation on milk composition of lactating she-camels in the experimental groups.

Milk composition (%)	G1 (control)	G2 (0.5 mg/kg DM)	G3 (0.8 mg/kg DM)	G4 (1.0 mg/kg DM)
Fat	4.63±0.10[a]	4.04±0.10[b]	4.40±0.05[a]	3.84±0.14[b]
Protein	3.64±0.05[b]	3.87±0.02[b]	3.75±0.12[b]	4.11±0.07[a]
Lactose	4.59±0.06[b]	4.87±0.06[a]	4.70±0.03[b]	4.99±0.04[a]
Ash	0.84±0.01[c]	0.87±0.01[b]	0.85±0.02[c]	0.92±0.04[a]
Total Solids	13.70±0.14	13.65±0.12	13.68±0.13	14.16±0.22
Solid not-fat	9.07±0.10[c]	9.61±0.05[b]	9.29±0.15[c]	10.02±0.07[a]
Iodine (µg/l)	78.20±3.74[d]	93.16±2.40[c]	108.66±3.17[b]	129.09±3.12[a]

Means in the same row with different superscripts are significantly different at P<0.05.

*** After parturition.**

Todorova *et al.* (1995) found that decreasing milk fat, protein yield in ewes were associated with iodine deficiency. Ehlers *et al.* (1994) observed a trend towards higher milk protein yield attributed to higher thyroxin for dairy cows given diet supplemented with iodine. Kobeisy *et al*. (1992) found that buffaloes treated with iodine increase percentages of milk constituent (protein and lactose) compared the control group. On the other hand, other authors indicated insignificant differences were observed in milk composition in iodine treated groups (Nudda *et al*., 2009; Norouzian *et al.*, 2009). Increasing iodine level in milk of treated groups was illustrated Friedrich *et al*., 2009), who reported that the concentration of iodine in milk depends mainly on the concentration of iodine in the diets in cows.

Blood parameters:
Blood biochemicals:

Biochemical blood parameters, including concentrations of total proteins (TP), albumin (AL), globulin (GL) and glucose (GLU) during pre and post-partum periods were higher in treatment groups than in control one, but the differences were not significant concentrations of TP, AL, Gl and GLU were higher in post- than in pre-partum period (Table 5).

The observed tendency of increase in concentration of TP and their fraction is in agreement with several authors, who mentioned that serum TP, AL and GL tended to be higher by iodine supplementation. (Shetaewi *et al*., 1991; Vsyakikh *et al*., 1992; El–Hosseiny *et al*., 2008).

Table (5): Concentrations of some biochemicals in blood plasma of lactating she-camels as affected by iodine supplementation in different experimental groups.

Item	G1 (control)	G2 (0.5 mg/kg DM)	G3 (0.8 mg/kg DM)	G4 (1.0 mg/kg DM)
Pre-partum period:				
Total proteins (g/dl)	7.04±0.19	7.31±0.12	7.37±0.11	7.89±0.35
Albumin (g/dl)	3.17±0.52	3.57±0.14	3.87±0.41	3.83±0.23
Globulin (g/dl)	3.86±0.64	3.73±0.22	3.50±0.52	4.06±0.16
Glucose (mg/dl)	48.88±0.88	51.98±2.75	54.65±1.89	56.65±4.09
Cholesterol (mg/dl)	84.78±1.80	85.78±2.85	79.28±5.77	75.04±2.85
Triglycerides (mg/dl)	101.20±1.36	106.0±3.51	103.8±3.39	109.0±2.51
Iodine (µg/l)	4.53 ± 0.37^d	7.27 ± 0.72^c	12.82 ± 0.92^b	19.58 ± 1.33^a
Post-partum period:				
Total proteins (g/dl)	7.83±0.40	7.79±0.46	8.28±0.22	8.34±0.24
Albumin (g/dl)	3.99±0.44	3.73±0.14	3.98±0.24	4.05±0.36
Globulin (g/dl)	3.83±0.05	4.06±0.41	4.30±0.25	4.28±0.12
Glucose (mg/dl)	60.03±4.01	66.12±4.49	64.57±5.32	71.54±4.19
Cholesterol (mg/dl)	91.76±2.94	89.30±1.70	85.30±4.06	81.46±3.56
Triglycerides (mg/dl)	102.12±1.63	108.00±3.51	109.60±4.41	111.60±4.04
Iodine (µg/l)	5.34 ± 0.71^d	9.30 ± 0.73^c	16.74 ± 1.07^b	24.72 ± 1.27^a

Means in the same row with different superscripts are significantly different at P<0.05.

Regarding glucose concentration, Bedi *et al*. (2000) found that glucose concentrations was significantly higher (P<0.01) in treated potassium iodide groups as compared to control. Also many investigators reported higher glucose concentration in iodine supplemented groups than in control one (Kobeisy and Shetaewi, 1992; Draganov *et al*., 1991; Vsyakikh *et al*., 1992). The observed increase in blood GLU was associated with an increase in milk lactose synthesis and a consequent increase in milk lactose content of treatment groups (Table 4). This results may be due to the high demand for energy especially glucose as a main source of energy during late pregnancy. The recorded trend of increase in TP and their fractions as well as in GLU concentration may be attributed to increasing thyroid hormones, which stimulates the basic metabolic rate through regulation of the metabolism of carbohydrates and proteins (Lawrence and Fowler, 1997). Also, Davis *et al*. (1988) found that T_4 injection increased mammary glucose uptake by 45%. Increasing GLU level in post- than in pre-partum period in he-camels was reported by El-Malky (2007) in Egyptian buffaloes, indicating a heavy demand for GLU in late gestation (Manston and Allen, 1981).

Data in Table (5) showed that no significant differences were noticed between treated groups and control one in triglycerides (TG) and cholesterol (CHO) concentrations. On the other hand, plasma iodine concentration significantly (P<0.05) increased in treated groups compared with control group, being significantly (P<0.05) the highest in G4. However, slight changes in TG and CHO concentration and marked increase in iodine concentration were observed in pre- as compared to post-partum period. In accordance with the obtained results, Davis *et al.* (1988) reported that no detectable effect of thyroxin injection on TG concentration. In line with our results, Aghwan *et al.* (2013) reported that supplemented iodine demonstrated positive results, in term of iodine concentration in serum of goat. Also, Aghwan *et al.* (2012) demonstrated that, rising iodine concentration in the serum resulted in increased iodine content in the muscles and organs of supplemented goats.

Blood hormones:

Table (6) showed that T_3 during pre- and post-partum and estradaiol-17β (E_2) concentrations during pre-partum period were significantly (P<0.05) higher in treated groups than in control one, being the highest in G4. However, concentration of T_4 and progesterone (P_4) concentrations were not affected significantly by treatment. On the other hand, iodine concentration in blood plasma significantly (P<0.05) increased during pre- and post-partum months, based on level of iodine treatment. It is of interest to note that T_3, T_4 and E_2 concentrations showed slight changes in post-partum as compared to pre-partum period. Meanwhile, P_4 concentration increased and iodine concentration decreased during pre- as compared to post-partum period.

Table (6): Concentrations of blood plasma parameters of lactating she-camels as affected by iodine supplementation in different experimental groups.

Item	G1 (control)	G2 (0.5 mg/kg DM)	G3 (0.8 mg/kg DM)	G4 (1.0 mg/kg DM)
Pre-partum period:				
T_3 (ng/dl)	95.42±4.20[c]	106.30±3.03[b]	113.10±2.39[ab]	118.06±2.05[a]
T_4 (ng/dl)	3.07±0.67	3.82±0.49	3.94±0.72	4.58±0.62
Progesterone (ng/dl)	4.32±0.03	3.79±0.61	4.28±0.60	4.48±0.27
Estradaiol-17β (pg/dl)	41.12±1.50[d]	63.17±6.45[c]	87.59±5.57[b]	105.59±2.86[a]
Iodine (µg/l)	4.53±0.37[d]	7.27±0.72[c]	12.82±0.92[b]	19.58±1.33[a]
Post-partum period:				
T_3 (ng/dl)	91.42±1.88[c]	110.46±3.83[b]	119.06±4.53[ab]	125.46±4.69[a]
T_4 (ng/dl)	3.47±0.63	4.20±0.72	4.34±0.60	5.48±0.80
Progesterone (ng/dl)	2.05±0.38	2.71±0.25	2.71±0.24	2.65±0.35
Estradaiol-17β (pg/dl)	40.87±2.68	47.61±7.43	51.63±4.99	55.47±3.79
Iodine (µg/l)	5.34±0.71[d]	9.30±0.73[c]	16.74±1.07[b]	24.72±1.27[a]

Means in the same row with different superscripts are significantly different at P<0.05.

Regarding to concentrations of thyroid hormones, Norouzian *et al.* (2009) and Rose *et al.* (2007) showed that iodine supplementation to ration of animals increase the concentrations of both T_3 and T_4 in blood. In our study, only T_3 concentration in animals treated with iodine, but T_4 showed a tendency of increase in treated groups as compared to control one. This increase may be due to increasing the availability of iodine to the thyroid gland to meet the demand of thyroid hormone during pregnant and lactation period.

The diminished level of P_4 before parturition was also stated earlier by several authors (Kamonpatana *et al.,* 1981; Perera, 1981) working on buffaloes. Smith *et al.* (1973) reported that the decline of P_4 stimulates the uterus to be under estrogen dominance at a time when coordinated uterine contractions begin in cattle. The importance of P_4 drop before onset of calving is to prevent the inhibitory effect of P_4 upon myometrial contraction as well as the release of oxytocin (Batra *et al.,* 1982). In this respect, El- Wardani *et al.* (1998) found that E_2 concentration in blood increases concomitantly with the decline in 4 concentration. Prakash and Madan (1986) mentioned to normal expulsion of fetal membranes requires a rise in E_2 before calving accompanied by a gradual and sustained fall in P_4. Moreover, normal calving requires softening and dilation of the cervix, particularly during late pregnancy due to the influence of relaxin and E_2 when P_4 dominance decline and uterine prostaglandin production is increasing (Taverne, 1992). In accordance with the obtained results, Zeedan *et al.* (2010 and 2012) found that E_2 concentration in blood of buffalo cows treated with iodine was significantly (P<0.05) higher than in control one at late pregnancy and during postpartum period, while level of plasma P_4 was lower in treated animals than in controls during pre-partum period.

It is worthy noting that T_3 and T_4 concentrations are in association with each of plasma iodine level and dose of iodine treatment in each experimental group (Kaneko, 1989).

Reproductive performance:

Table (7) showed that iodine treatment at a level of 1 mg/kg DM (G4) significantly (P<0.05) improved the reproductive performance of lactating camels, in terms of the shortest time of the 1st heat onset, number of services per conception (NSC), days open (DO), time of placental drop, uterine involution and calving interval, and the highest conception rate (CR).

The positive impact of iodine supplementation on reproductive performance of camels as proved in our study was similar to that occurred in buffaloes by Zeedan *et al.* (2010 and 2012). Also in buffaloes, estrus signs and CR (Sushma-Chhabra *et al.,* 2007) reproductive efficiency (Mavi and Bahga, 2005) were improved by iodine treatment. Moreover, Panchal *et al.* (1991) revealed to the overall pregnancy rate was highly significant in the iodine treated groups (42.17%) than that of the control group (17.05%). These finding indicated that good reproductive efficiency, postpartum estrus interval, service period and NSC were observed in animals with plasma protein bound iodine group and consequently high iodine level in blood.

Table (7): Reproductive performance of lactating she-camels as affected by iodine supplementation in different experimental groups.

Item	G1 (control)	G2 (0.5 mg/kg DM)	G3 (0.8 mg/kg DM)	G4 (1.0 mg/kg DM)
Onset of 1st heat (day)	68.4±3.5[a]	57.2±5.91[a]	62.8±4.78[a]	40.2±3.43[b]
Number of services/conception	4.0±0.37[a]	3.2±0.25[ab]	4.2±0.24[a]	2.6±0.40[b]
Day open (day)	278.2±3.73[a]	232.4±6.24[c]	257.4±2.50[b]	182.8±5.14[d]
Conception rate (%)	40	60	80	100
Duration of placental drop (min)	175.6±3.37[a]	165.2±3.35[ab]	168.0±5.44[ab]	157.2±3.44[b]
Uterine involution (day)	50.0±2.17[a]	42.0±2.88[b]	46.0±1.61[ab]	30.6±1.86[c]
Calving interval (day)	529.8±3.77[a]	498.4±5.78[b]	522.0±4.64[a]	456.0±8.57[c]

Means in the same row with different superscripts are significantly different at P<0.05.

Calves performance from birth to weaning:

Table (8) showed insignificant effect of iodine treatment on body weight of dams around periparturient period. At calving, weight of fetal fluids and placenta was higher in treated than in control animals, but the differences were significant (P<0.05) for placental weight, being the heaviest in G4. Regarding camel calf performance the effect of treatment was not significant on body weight at birth or weaning, but average daily or total gain of calves was significantly (P<0.05) the highest in G4 as compared to other treatment or control groups. These results can be due to improvement of thyroid function, increasing concentrations of immunoglobulin in colostrum's, increasing milk protein and milk lactose which led to increase in growth performance of camel calves.

Table (8): Effect of iodine supplementation on growth performance of she-camels and newborn calves.

Item	G1 (control)	G2 (0.5 mg/kg DM)	G3 (0.8 mg/kg DM)	G4 (1.0 mg/kg DM)
Average weight of she-camels (kg):				
Before parturition	492.4±10.39	490.2±4.53	506.2±3.34	491.0±5.72
After parturition	439.0±7.71	434.4±4.77	451.5±4.15	433.8±4.46
Average weight (kg)				
Fetal fluid	10.94±0.16	11.70±0.27	11.10±0.34	11.90±0.43
Placenta	$3.60±0.07^{c}$	$3.90±0.07^{ab}$	$3.80±0.07^{bc}$	$4.06±0.09^{a}$
Average weight of born calves (kg):				
At birth	38.9±3.02	40.2±1.99	39.8±4.69	41.2±2.33
Relative to dam weight %	8.83±0.59	9.26±0.51	8.84±1.11	9.50±0.54
At weaning	139.5±3.15	151.0±3.03	148.6±2.63	162.7±3.37
Total gain up to weaning	$100.6±1.37^{b}$	$110.8±1.85^{ab}$	$108.76±5.39^{b}$	$121.5±4.55^{a}$
Daily gain up to weaning (g/day)	$0.66±0.01^{c}$	$0.72±0.02^{b}$	$0.70±0.01^{bc}$	$0.78±0.01^{a}$

Means in the same row with different superscripts are significantly different at P<0.05.

In consistent with the present results, Gilles *et al*. (2009) found that selenium and iodine administration during pre-partum period may enhance the calf immune defenses by improving the maternal mineral status in cows. Also in cattle, Sultana *et al*. (2006) found the highest live weight gain was found in Lugol's iodine treated group, which may be due to anabolic effect of iodine on weight gain. In this way, Hoption (2006) reported that thyroid hormones play a major role in the growth and control of several metabolic processes including carbohydrate, fat, protein, vitamin and mineral metabolism. Also, Monget and Monniaux (1995) reported that iodine deficiency affected on growth by which effect on metabolic activity of body.

Iodine supply increase the function of thyroid gland and increase body metabolic activity and body weight. McDowell (2003) found that thyroid hormones have multiple functions in the energy metabolism of cells and growth. Also, Gasanov (1991) found that buffaloes supplemented with potassium iodide had increased calf birth weight and decreased calving problems. Zeedan *et al.* (2010 and 2012) found that birth and weaning weight of calves in groups treated with iodine were higher than that of control group. Zimmermann (2009) found that iodine deficiency during pregnancy period may decreases growth of offspring and increase mortality rate. Guyot *et al.* (2011) reported that iodine transferred from the dam to the new born calve through placenta transmission rather than colostrum transfer, adding that dams supplemented with iodine improving newborn status.

IV. Conclusion

Iodine supplementation to the ration of she-camel can considerably increase milk iodine and may therefore contribute to improving the human iodine supply. Milk and serum iodine concentrations vary with application of potassium iodide concentrations. The blood and milk iodine may pretend a better iodine supply of the animal than existent. Iodine supplementation at level of 1.0 mg potassium iodide per kg DM/h/d tended to improve the immunity and performance of calves, milk production and its composition and reproductive performance of lactating she-camels.

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Abd El-Salaam"Impact of dietary iodine supplementation on productive and reproductive performance of Maghrebian She-camels"IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS) 11.3 (2018): PP 59-69