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The Effect of Feeding Different Levels of Potassium Iodide on Performance, T_3 and T_4 Concentrations and Iodine Excretion in Holstein Dairy Cows

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Abstract: Sixteen Holstein dairy cows with the average live body weight of 652±43 and daily milk yield of 32.9±2.4 kg allocated to 4 treatments in a complete randomized design with 4 replications to evaluate the effect of iodine supplementation on performance of dairy cow and iodine excretions especially in milk. The treatments were: basal diet (without Potassium Iodide) as the control diet, 2, 3 and 4, the basal diet plus 2.5, 5 and 7.5 mg kg^{-1} diet DM Potassium Iodide, respectively. There were no significant difference between treatments for dry matter intake, milk yield and compositions and the milk production efficiency. Iodine contents in blood, urine, raw and pasteurized milk were significantly ($p<0.01$) affected by the iodine supplementation. Blood T_3 and T_4 concentrations were not significantly affected by the treatments. No adverse effect of iodine supplementation on performance and health of dairy cow were detected in this study. It was concluded that iodine supplementation above of NRC recommendation (0.5 mg kg^{-1} diet DM) led to a desirable level of iodine in the milk ready for human consumption without adverse effects on dairy cows performance and health. This finding could be an excellent recommendation for the area with iodine deficiency mainly for children's.

Key words: Potassium iodide, thyroidal hormones, iodine requirement, human health

INTRODUCTION

Iodine is an essential dietary element for mammals, required for the synthesis of the thyroidal hormones; thyroxin (T_4, 3, 5, 3', 5'-tetraiodothyronine) and its active form, T_3 (3, 5, 3'-triiodothyronine). Thyroidal hormones play a major role in the growth and development of brain and central nervous systems, control of several metabolic processes including carbohydrate, fat, protein, vitamin and mineral metabolism. Iodine deficiency affects reproductive capacity, brain development and progeny as well as growth (Hoption, 2006).

Higher dietary iodine supply results in increasing iodine excretion mainly by urine, milk and eggs and to a considerably smaller extent in body deposition (except sea food).

The amount of Iodine in milk, which is consumed by humans, especially by infants, has been reported as an issue of concern for its effects on human health (Hoption, 2006). Nowadays Milk and dairy products are an important source of iodine for human.

Iodine concentration of cow milk can be influenced by its concentration in the diet or pasteurization process. A linear correlation between iodine content of the diet and cow milk has been reported (Hemken *et al.*, 1972; Fish and Swanson, 1982; Lisbeth *et al.*, 2003). This study was conducted in order to elevate the effects of High levels of dietary iodine on performance, thyroidal hormones, iodine concentration of milk in Holstein cow and study the effects of pasteurization process on iodine content in milk.

MATERIALS AND METHODS

Sixteen Holstein cows, with an average daily milk yield of 32.9±2.4 kg and 189±27 days in milk, were assigned to 4 treatments in a completely randomized design. The experimental diets were the control, the control diet plus 2.5, 5 and 7.5 mg Potassium Iodide/kg diet DM. The experiment lasted after 8 weeks. Diets were formulated accordance to NRC, 2001 recommendations (Table 1 and 2). The content of iodine in basal diet was

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0.534 mg kg^{-1} DM and other treatments included basal diet plus different levels of iodine supplementation (Table 2). The iodine content of blood, urine, raw and pasteurized milk, weekly and blood thyroidal hormones (T_3 and T_4), monthly was determined. The dry matter intake, milk yield and compositions were measured for all treatments. For measurement of milk composition (fat, protein, lactose and SNF) used of MilkoAnalyzer (ViA StElle, 11-25020 PoN (ARA4ecBS). For determination of iodine in urine, raw and pasteurized milk, in the end of any week, 10 mL of samples saved in 4°C until send to laboratory. Milk pasteurized by HTST method. In the first day and 4 week periods of experiment, samples were obtained between 3 h after morning feeding with vein injects tubes (Pars Darrow, Iran). Blood samples were centrifuged at 15000×g for 15 min and the plasma was frozen at -20°C. The amounts of thyroidal hormones were calculated with RIA kit (Kimia Phaksh Shargh, Iran). For determination of iodine, after acid digestion, used of Sandell-Kolthoff reactions (Endocrine Research Center, Shaheed Beheshti University of Medical Sciences, Tehran, Iran). Any clinical sings result of poisoning with iodine was controlled by veterinarian. Data were statistically analyzed by repeated measurement procedure with mixed model of SAS software. The statistical model that using in this study was:

$$Y_{ijk} = \mu + D_i + C_{(i)\,j} + T_k + (D \times T)_{ik} + \varepsilon_{ijk}$$

Y_{ijk} = Dependent variable
μ = Overall mean
D_i = The effect of treatment
$C_{(i)\,j}$ = Random effect of cow in diet
T_k = Effect of sampling week
$(D\times T)_{ik}$ = Interaction between treatment and sampling week
ε_{ijk} = Experimental error

Table 1: Ingredient composition of diets fed to cows during experimental period (% diet DM)

		Diets*		
Ingredient	Control	2	3	4
Alfalfa hay	21.0	21.0	21.0	21.0
Corn silage	23.0	23.0	23.0	23.0
Barley grain	14.0	14.0	14.0	14.0
Corn grain	12.0	12.0	12.0	12.0
Cottonseed meal	9.5	9.5	9.5	9.5
Soybean meal	8.0	8.0	8.0	8.0
Wheat bran	7.0	7.0	7.0	7.0
Sugarcane bagasse	4.5	4.5	4.5	4.5
Urea	0.2	0.2	0.2	0.2
Limestone	0.4	0.4	0.4	0.4
Vit. Min. supplementation**	0.2	0.2	0.2	0.2
Salt	0.2	0.2	0.2	0.2
Potassium iodide (mg kg^{-1} DM)	-	2.5	5.0	7.5

*Control: diet without Potassium Iodide, 1: diet containing 2.5, 2: Diet containing 5 and 3: diet containing 7.5 mg Potassium Iodide kg^{-1} DM; **Contained Common supplementation of minerals and vitamins

Table 2: Chemical composition of diets fed to cows during experimental period

		Diets			
Item	Unit	1	2	3	4
DM	(%)	65.15	65.15	65.15	65.15
NEL	Mcal kg^{-1}	1.58	1.58	1.58	1.58
CP	(%)	15.6	15.6	15.6	15.6
UDP	CP (%)	35	35	35	35
NDF	(%)	34.9	34.9	34.9	34.9
eNDF	(%)	24.8	24.8	24.8	24.8
ADF	(%)	20.4	20.4	20.4	20.4
NFC	(%)	36	36	36	36
Ca	(%)	0.61	0.61	0.61	0.61
P	(%)	0.39	0.39	0.39	0.39
Na	(%)	0.13	0.13	0.13	0.13
Cl	(%)	0.29	0.29	0.29	0.29
DCAD	mEq kg^{-1}	+290	+290	+290	+290
Ca/P		1.56	1.56	1.56	1.56
I*	mg kg^{-1}	0.534	3.034	5.534	8.034

*The iodine content of each diet was including iodine Diet, Water and Iodine supplementation

RESULTS AND DISCUSSION

Dry Matter Intake (DMI): No significant difference was observed between treatments for DMI (kg d^{-1} or percent of BW) (Table 3). Decrease of dry matter intake related to feeding high levels of iodine was seen in calves. Newton *et al*. (1974) and Jenkins and Hidiroglou (1990) reported that feeding 10-50 and 100 mg kg^{-1} DM iodine in calve cause to decrease DMI. Fish and Swanson (1982) found that feeding high levels of iodine to calve cause to decrease in DMI as kg d^{-1} not as percent of BW and feed efficiency.

Milk yield and composition: Milk yield and composition values in different treatments are shown in Table 3. No significant differences observed in all treatment, for milk

Table 3: Least square mean of performances of cows which were fed experimental diets

	Diet					Effect	
Ingredient	1	2	3	4	SEM	Diet	Period
DMI (kg d^{-1})	20.9	20.56	19.93	20.64	0.264	0.121	<0.01
DMI (BW%)	3.30	3.100	2.970	3.360	0.123	0.149	<0.01
Milk (kg d^{-1})	27.84	28.02	26.53	27.57	1.403	0.897	<0.01
Milk* (kg d^{-1})	24.15	25.01	25.57	25.20	1.070	0.813	<0.01
Milk fat (kg d^{-1})	0.872	0.886	0.961	0.941	0.048	0.532	<0.01
Milk fat (g kg^{-1})	30.81	31.12	35.54	33.87	0.150	0.135	<0.01
Milk protein (kg d^{-1})	0.875	0.873	0.826	0.866	0.044	0.847	<0.01
Milk protein (g kg^{-1})	31.57	31.17	30.98	31.48	0.682	0.920	0.229
Milk Lactose (kg d^{-1})	1.296	1.300	1.243	1.286	0.064	0.919	<0.01
Milk Lactose (g kg^{-1})	46.81	46.72	46.50	46.84	0.869	0.992	0.174
Milk SNF** (kg d^{-1})	2.40	2.420	2.28	2.370	0.123	0.861	<0.01
Milk SNF (g kg^{-1})	86.43	86.57	85.55	86.41	1.550	0.964	<0.01
Milk efficiency***	1.15	1.21	1.27	1.210	0.053	0.485	<0.01

*Fat Corrected Milk for 4% fat (FCM), **Solid not Fat (SNF), ***Milk (FCM) yield per kg DMI

Table 4: Least square mean of iodine concentration in urine, blood plasma, milk and thyroidal hormones

	Diet					Effect	
Item	1	2	3	4	SEM	Diet	Period
Urine Iodine (μg L^{-1})	59.5[a*]	364.250[b]	601.690[c]	681.88[c]	19.060	<0.010	<0.010
Blood Iodine (μg L^{-1})	177.37[a]	326.870[b]	339.620[b]	381.37[c]	14.370	<0.010	<0.010
Raw milk Iodine (μg L^{-1})	142.61[a]	430.860[b]	545.430[c]	593.32[c]	15.380	<0.010	<0.010
Pasteurized milk Iodine (μg L^{-1})	67.43[a]	306.940[b]	367.560[b]	466.88[c]	26.470	<0.010	<0.010
Blood T_3 (ng L^{-1})	90.75	91.125	99.500	104.75	13.960	0.867	0.412
Blood T_4 (μg dL^{-1})	3.00	2.675	3.237	2.80	0.304	0.597	0.235

[*]Means in the same row with different superscripts are significantly different ($p<0.01$)

yield and milk composition. Grace and Waghorn (2005) used of three intramuscular injection of iodized oil that contain 2370 mg iodine per any dose, in period 100 days. These authors reported any significant effects on milk yield and composition. Olson *et al.* (1984) found 15% decrease in milk yield with use of 440 mg EDDI kg^{-1} DM. These results shown by other authors with use iodine levels up to 300 mg kg^{-1} DM (Hillman and Curtis, 1980). It may be that feeding levels up to 300 mg kg^{-1} DM iodine in dairy cow result to decrease in performance. The levels of iodine that applied in this study were very lower than amount of iodine that cause to poisoning and decreases of milk yield (Table 2).

Thyroidal hormones: Concentrations of T_3 and T_4 hormones between different diets are shown in Table 4. Different levels of iodine haven't any effect on thyroidal hormones concentration. In an experiment Convey *et al.* (1978) showed any changes in thyroidal hormones after administering of iodine, 30 fold of requirement. In other study Swanson *et al.* (1990) used of iodine supplementation in 1, 2 and 4 mg Potassium Iodide kg^{-1} DM.

These authors weren't observed any changes in T_3 and T_4 concentration. Pituitary gland control concentration of thyroidal hormones via TSH. Therefore, if iodine level in blood increases, additive of iodine excrete via urine and milk mostly (Swanson *et al.*, 1990).

Iodine measurements: Iodine concentrations between treatments are shown in Table 4. In all items, the increase of iodine amounts were affect significantly ($p<0.01$). Iodine in blood in 1st week of experiment was increase sharply but this trend wasn't observed for urine and milk that indicate the rapid transformation iodine between diet and blood. Milk is an important way for excretion of additive iodine in body and increase of iodine intake cause to increase in excretion via milk. Results of 17 studies with radioisotope iodine were shown that the excretion ratio of iodine via milk is 8-12% of iodine intake (Swanson *et al.*, 1990). Therefore, there is linear relationship between iodine intake and iodine concentration in milk.

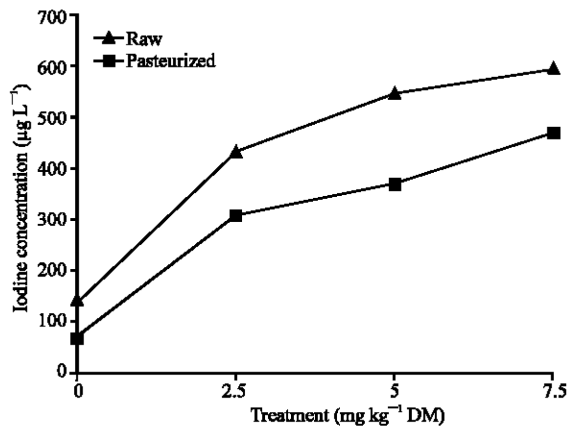

Fig. 1: Iodine concentration of the raw and pasteurized milk

Effect of pasteurization on milk iodine concentration: Decrease of iodine content in all treatments after pasteurization were significant ($p<0.01$). Average decrease of iodine after pasteurization was 27.15±7.13% (Table 4 and Fig. 1).

Magee and Glennie (1928) found 20 and 26% decrease of iodine content of milk in pasteurization and boil point, respectively. The reason of decrease of iodine concentration after heat processing is sublimation characteristic of iodine element. Iodine in milk includes tow forms, Protein Binding Iodine (PBI) and free. Magee and Glennie (1928) reported that free form of iodine in milk is 83%. High amount of iodine in free form in milk cause to decrease of iodine content after heating.

CONCLUSION

Because of the linear increasing of iodine concentration of cow milk and any adverse effects of high levels of Potassium Iodide on performance and health of dairy cows, it seem that we can be able to increase iodine milk concentration by change in amount and kind of iodine source that used in mineral supplementation related to supply the human requirements especially in children's. It is possible to educate the farmer for inclusion the appropriate amount of iodine in the dairy diets in accordance with the consumer's need.

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