Iodine carry over in dairy cows: effects of levels of diet fortification and milk yield

Marco Battaglia, Maurizio Moschini, Gianluca Giuberti, Antonio Gallo, Gianfranco Piva, Francesco Masoero

Istituto di Scienze degli Alimenti e della Nutrizione, Università Cattolica del Sacro Cuore, Piacenza, Italy

Corresponding author: Maurizio Moschini. Istituto di Scienze degli Alimenti e della Nutrizione, Facoltà di Agraria, Università Cattolica del Sacro Cuore. Via Emilia Parmense 84, 29100 Piacenza, Italy – Tel. +39 0523 599192 – Fax: +39 0523 599259 – Email: maurizio.moschini@unicatt.it

ABSTRACT - Thirty multiparous lactating cows were divided in three groups based on milk yield: high (H), average (A) and low (L). Within each group, cows were randomly allotted to two levels of iodine inclusions into the diet and respectively: level 1 (1): base diet containing 1.55 mg/kg dry matter, level 2 (2): base diet plus 47.2 mg/d. Potassium iodide was used. Feeds, orts, drinking water and individual milk samples were collected and analysed for the iodine content. The iodine concentration and total excretion in milk were affected by the level of iodine supplementation ($P<0.05$). No effect on milk iodine concentration could be addressed either to the level of milk yield or to the milk yield x treatment interaction. The total amount of iodine excretion and carry over were affected ($P<0.05$) by the level of milk yield.

Key words: Iodine, Milk, Carry over.

Introduction – Iodine is an important element for the thyroid gland metabolism efficiency. The iodine deficiency leads to several diseases grouped as Iodine Deficiency Disorders (IDD): a concern not only for developing countries but also for Europe, where about 16.7% of the population is at risk for IDD (Vitti *et al.,* 2001). Besides the optimal role of the salt-iodization policies, it is clear the important relation between milk intake and iodine status in children (Vitti *et al.*, 2001; Girelli *et al.,* 2004). The cow milk iodine concentration ranges between 30 and 300 µg/L and the optimal iodine feed concentration is 0.45 mg/Kg dry matter (NRC, 2001). The iodine milk content may also change due to regional variation (Pennington, 1990) and the stage of lactation (Swanson, 1972). The objective of this work was to evaluate the iodine carry over (CO) into milk and how the milk concentration would be affected by the milk yield and the lactation stage of cows.

Material and methods – Thirty multiparous lactating cows, housed at the CERZOO research and experimental centre (San Bonico, Piacenza, Italy), were allotted to three groups (10 animal each) according to the milk yield and stage of lactation. Groups were High milk yield (H): 44.0±2.9 kg milk yield and 137±17 days in milk (DIM), Average milk yield (A): 31.7±1.8 kg milk yield and 207±47 DIM, Low milk yield (L): 24.2±2.7 kg milk yield and 245±57 DIM. Within each group, cows were randomly allotted to two levels of iodine (potassium iodide) supplementation, individually poured as a single water solution (10 ml/cow) on top of the total mixed ration (TMR) just after the morning distribution. The levels of iodine were level 1 (1), base diet; level 2 (2), base diet plus 47.2 mg/d of iodine. The base diet was formulated according to the nutrient requirements of dairy cattle (NRC, 2001) for an average cow weight of 600 kg, 140 DIM and a 35 kg milk yield (3.8% fat and 3.35% protein). All cows received the same TMR with a forage to concentrate ratio of 40:60 on the DM basis and made of corn silage, dehydrated alfalfa, grass hay, cotton seed, corn meal, barley meal, soybean meal, calcium soap and a protein mineral supplement. There were two weeks of adaptation period to a common base diet followed by a 16 days of treatment period in which the iodine supplementation was given to cows assigned to level 2. The given TMR and refusals were weighed daily on a group base and the average week intake was calculated. Post-dipping treatments were performed with a commercial clorexidine spray solution with no iodine. Feeds used in the TMR were sampled, dried in a ventilated oven (65°C) for 72 hours, then ground to a 1 mm sieve before being analysed for the iodine content. Individual milk samples were collected weekly at each milking, proportionally mixed by animal and day, then frozen at -20°C before being analysed for the iodine content. The drinking water was monitored for the iodine content. The iodine feed samples were prepared according to Flachowsky *et al.* (2007) whereas milk and water according to Sanchez & Szpunar (1999). The analytical determinations was done by ICP-MS (Inductively Coupled Plasma – Mass Spectrometry, ICP-MS Agilent 7500ce, CA, USA) using the Rh as internal standard. All the reagents and solutions were prepared using ultrapure water (Millipore Milli-Q® plus 18,2 Mωcm). The Certified Reference Material BCR 151 (Community Bureau of Reference, Brussels, Belgium) containing 5.35±0.14 µg iodine /g was used for milk iodine content determination. The method of internal standard was used for all iodine assays. The iodine CO in milk was calculated at the second week in treatment as CO=Total iodine excretion (mg) / (Total iodine in feeds (mg) + iodine addition (mg)). The response variables that were measured over time (iodine ingestion, concentration and, total excretion in milk and CO) were subjected to ANOVA using the repeated statement in the mixed procedure of SAS (SAS Inst. Inc., Cary, NC, release 9.1) in a completely randomized design with a factorial approach. The statistical model included fixed effects of group for milk yield, the level of iodine ingestion, the time of sampling and the milk yield x time of sampling and milk yield x level of iodine ingestion x time of sampling interactions with cow as the random variable. Each variable analyzed was subjected to three covariance structures: being SP(POW), compound symmetry and unstructured. Using the Akaike information criterion and the Schwarz Bayesian criterion, the compound symmetry was the covariance structure that best fitted the model. Significance was declared at $P<0.05$ and a trend at $0.05<P<0.1$.

Table 1. Iodine concentration, total excretion and carry over (CO) in milk in animals with different level of milk yield and iodine supplementation (n=5)

		Groups						s.e.
		L1	L2	A1	A2	H1	H2	
Iodine ingested	mg/d	33.15	79.74	31.94	79.14	34.97	82.17	0.389
Iodine concentration in milk	µg/L	223.09	566.31	226.90	655.41	241.30	561.92	49.572
Iodine excretion in milk	mg	4.64	12.23	6.61	18.77	9.07	22.41	1.460
Iodine CO in milk	%	14.07	15.40	20.70	23.74	25.92	27.29	0.023

*ns=non-significant; †P<0.10; *P<0.05; **P<0.01; ***P<0.001. Statistical significance of effects of milk yield (Y), level of iodine inclusion (LEV), milk yield x level of iodine inclusion interaction (YxLEV), sampling (S) and milk yield x level of iodine inclusion x sampling interaction (YxLEVxS):*

- *Iodine ingested: Y=***, LEV=***, YxLEV=ns, S=***, YxLEVxS=***.*
- *Iodine concentration in milk: Y=ns, LEV=***, YxLEV=ns, S=**, YxLEVxS=†.*
- *Iodine secretion in milk: Y=**, LEV=***, YxLEV=ns, S=***, YxLEVxS=†.*
- *Iodine CO in milk: Y=***, LEV=ns, YxLEV=ns, S=***, YxLEVxS=ns.*

Results and conclusions – The average milk yields during the experimental period were 21, 29.1 and 38.7 kg/cow/day, whereas the DM intakes were 21, 20.6 and 22.6 kg/cow/day, respectively for the L, A and H groups. The average iodine contents of the base TMR was 1.55 mg/kg DM. The level of iodine inclusion into the diet affected (*P*<0.05) the iodine concentration and total excretion in milk. There was no effect on milk iodine concentration, either from the level of milk yield or the milk yield x treatment interaction confirming the results of Alderman and Stranks (1967). Daburon *et al.* (1989) reports a relation between milk iodine concentration and stage of lactation in cows given a chronic iodine amount. However, in presence of limited supply of iodine, the amount secreted through the mammary gland can be effectively reduced by the animal to prevent the reduction of thyroxin (Swanson, 1972). The total amount of iodine excretion in milk and CO were affected (*P*<0.05) by the level of milk yield. The iodine concentration in milk seems independent from the milk yield but could be raised by increasing the cow supplementation.

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REFERENCES – Alderman, G., Stranks, M.H., 1967. The iodine content of bulk herd milk in summer in relation to estimated dietary iodine intake of cows. J. Sci. Food. Agr. 18, 151-153. **Daburon**, F., Fayart, G., Tricaud, Y., 1989. Caesium and iodine metabolism in lactating cows under chronic administration. Sci. Total Environ. 85, 253-256. **Flachowsky**, G., Schöne, F., Leiterer, M., Bemmann, D., Spolders, M., Lebzien, P., 2007. Influence of an iodine depletion period and teat dipping on the iodine concentration in serum and milk of cows. J. Anim. Feed Sci. 16, 18–25. **Girelli**, M.E., Coin, P., Mian, C., Nacamulli, D., Zambonin, L., Piccolo, M., Vianello-Dri, A., Gottardo, F., Busnardo, B., 2004. Milk represents an important source of iodine in schoolchildren of the Veneto region, Italy. J. Endocrinol. Invest. 27, 709-713. **NRC**, 2001. Nutrient requirements of dairy cattle, seventh revised edition. National Academy of Science, Washington, DC. **Sanchez**, L.F., Szpunar, J., 1999. Speciation analysis for iodine in milk by size-exclusion chromatography with inductively coupled plasma mass spectrometric detection (SEC-ICP MS). J. Anal. Atom. Spectrom. 14, 1697-1702. **Swanson**, E.W., 1972. Effect of dietary iodine on thyroxine secretion rate of lactating cows. J Dairy Sci. 55, 1763-1767. **Vitti**, P., Rago, T., Aghini-Lombardi, F., Pinchera, A., 2001. Iodine deficiency disorders in Europe. Public Health Nutrition 4(2B), 529-535.