Iodine in the milk – effects of iodine and rape seed feeds in the cow's diet and consequences for human nutrition

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Abstract

There is still iodine deficiency in many populations, which justifies efforts to increase the content of this trace element in food such as milk and eggs by fortifying the animal feed with extra iodine. Additionally to the amount of the trace element in the diet the milk-iodine concentration is affected by the occurrence of rape feeds. Former experiments with high and low glucosinolate rapeseed meal (RSM) in dairy cows (Papas et al., 1979) charakterized the glucosinolates as iodine antagonists, i.e. the milk iodine concentration was decreased by RSM feeding. Further dairy cow experiments with rapeseed feeds from 00 varieties either confirmed these findings (Emanuelson et al., 1993) or there was only a tendency of iodine milk concentration decrease and no effect on the total milk iodine amount in the milk amount per day (Jahreis et al.,1995).

The present study consisted of three parts. In the first part results of newer German studies of milk iodine concentration are presented. As second part, in a dose response experiment with lactating cows a broad range of iodine supplements was tested quantifying the effect of dietary iodine on the milk iodine concentration. As third part, the effect of a RSM with extremely low glucosinolate content should be tested on the milk iodine concentration.

Methods

The studies represented newer German investigations, as a rule in bulk milk from Thuringia and Bavaria.

In the dose-response experiment, five Holstein cows of the last lactation third were fed four iodine doses as calcium iodate-hexahydrate (with the mineral mixture, 150 g/d) in 4 periods of 14 days each. In addition to the testing of the diet without iodine supplement the supplementation levels were 15, 65 and132 mg iodine/cow/d corresponding to a total of 3, 17, 68 and 134 mg /day, i.e. 0.2 (basal diet), 1.3, 5.1 and 10.1 mg/kg dry matter (DM). Three milk samples per cow were taken during the last 5 days of each period; the daily milk yield amounted to 20 kg.

The RSM experiment consisted of two groups, with 24 Holstein-cows each, either without or with RSM (2 kg = 1.8 kg DM per animal and day) in the diet. Milk samples were taken from 9 cows of each group. The total mixed diets (Tab.1) contained in the control lupines as sole protein concentrate (18 % of the diet`s dry matter, DM), in the experimental group 11 % lupines + 8 % RSM (for details Kluth et al., 2005). The milk samples originated from the second experiment`s period – 12th. to 19th lactation week, 36 kg milk/ day (corrected for 4 % fat and 3.4 % protein), sampling after 5 weeks feeding of the respective diets.

The iodine analysis (Leiterer, 2001) was carried out applying the ICP-MS-technique (inductively coupled plasma mass-spectrometry) after a specific extraction of the freeze-dried milk with tetra methyl ammonium hydroxid (TMAH). The glucosinolate content of the RSM was analysed by HPLC (EU 1999, details by Rothe et al. 2004). The results are given as arithmetic mean and standard deviation The means were compared by the ANOVA and Dunnets test (dose response experiment) and by STUDENTs` t test (RSM experiment).

Results and discussion

Milk iodine concentration according to investigations of bulk milk samples

Due to the iodine supplementation of feed the milk iodine concentration increased from < 20 (Tab. 2) to > 100 µg/kg: Eastern Germany still during the beginning 1980s represents the example for a milk status without added iodine to the cow feed. Mean concentrations in the range of 100 to 200 µg iodine/kg milk show also further newer studies in Thuringia (Schöne et al. 2003, Bader et. al. 2005) and Saxony (Launer und Richter, 2005) with trends of decreased frequency of low iodine milk samples (<50 µg iodine/kg milk).

The German Society of Nutrition recommends a daily intake of 200 µg iodine for young people and adults (German Society of Nutrition… DACH 2000). One half litre of milk with 100 and 200 µg iodine/kg, resp., could contribute to the recommended amount at one quarter and one half, resp..

Milk iodine in dose response experiment

The milk iodine concentration did not differ between the sampling days (P=0.89 in the two way-ANOVA, not shown), however, the effect of dietary I dosage was significant. An about fourfold I supplementation in period 3 (65 mg I per day) as compared to period 2 (15 mg I per day) resulted in a 3.5 fold milk I concentration. A further doubling of the daily I dosage (132 mg I/day in period 3 versus 65 mg I/day in period 4) resulted in a further2.3 fold milk I concentration.

Relating the total iodine output represented by 20 kg milk/day to the ingested trace element, there was a transfer into the milk in a magnitude of 30 - 40 % in the three groups with the iodine supplements. In the period of no additional dietary iodine (only basal content), the transfer of three quarter related to the intake seems to be an artefact because the iodide resulting from the degradation of thyroid hormones would be effectively recycled (Schöne et al. 2001) and so it contributes to the milk iodine output in case of a dietary iodine deficit.

Effects of glucosinolates of RSM on the milk iodine concentration

The RSM contained 5,9 mmol glucosinolates/kg. The mineral mixture was labelled with 100 mg iodine /kg; one half year after the experiment only 59,6 mg iodine /kg were determined. Consuming as mean 230 g per day the mean daily iodine amount per cow via the mineral mixture with labelled content amounted to 23 mg iodine, i.e. 1 mg added iodine/kg DM with 23 kg DM as mean daily intake. Such dietary iodine represents the twofold concentration of 0. 5 mg iodine/ kg DM recommended by the GfE (2001).

Administering the RSM (0.4 mmol GSL/kg feed DM) significantly lowered the milk iodine concentration ($P< 0.001$), by about one half (162 ± 38 µg/kg milk) compared to the control group (356 ± 39 µg iodine/kg milk) with the diet free of rape feeds and glucosinolates, resp. (Fig.2). Inspite this milk iodine loss a concentration of significantly more than 100 µg iodine /kg milk also in the group with RSM points to adequate supply with the trace element.

Conclusion

In the dose-response experiment, the highest iodine feed supplement tested resulted in a milk iodine concentration exceeding the upper limit for human iodine consumption of 500 µg/d (German Society of Nutrition 2000) in case of the consuming only 250 ml of this fortified milk. As a result of this cow experiment, in the European Union the prevailing maximum iodine level of cow and hen diets was reduced from 10 mg/kg feed to 5 mg /kg feed (basis 880 g dry matter/kg diet). A cow experiment with solvent extracted RSM was presented in which already low amounts of glucosinolates decreased the milk iodine concentration. These effects of rape feeds confirm a glucosinolate iodine antagonism - however, in a new context of a possibly too high milk iodine concentration this effect is not *a priori* negative and contrasts with the traditional view of the glucosinolates in animal nutrition.

Table 1: Composition of the diets without and with rapeseed meal in the experiment with 24 cows per group. In both the groups the feed consumption amounted to 23 kg dry matter,DM /d.

Rapeseed meal	Without	With
Ingredients (% of the DM)		
grass silage, 1st cut	15.9	15.9
maize silage	39.3	38.6
straw	1.6	1.5
ensiled distillers grains	6.1	5.8
barley, crushed	15.7	15.9
lupines	18.3	10.9
rapeseed meal solvent extracted	-	8.4
mineral premix	1.0	1.0
rest[1]	2.1	2.0
Feed data		
NEL, MJ/kg DM	7.4	7.3
uCP g/kg DM	166	171
crude fiber g/kg DM	157	154

DM - dry matter, NEL – net energy lactation, uCP – (duodenally) utilizable protein (GfE, 2001) [1] propylene glycol, protected fat, lime stone, salt

Table 2: Studies in the iodine concentration of milk. In German Food Tables (Souci et al., 2000) 27 µg iodine/kg are given.

State, year	Number	0 ± s (Min. – Max.) Iodine µg/kg	Literature
Eastern Germany Before 1985[1)]	No numbers	17 ± 10	Anke et al. 1993
1987[2)]		53 ± 35	
1990[2)]		81 ± 11	
Bavaria 1995	368	114 (26 – 298)	Preiss et al. 1997
Thuringia 1996	61	111 ± 71 (15 –290)	Jahreis et al. 1999

[1)] before [2)] after the obligatory iodine addition to the mineral premixtures (cited in Flachowsky et al., 2006)

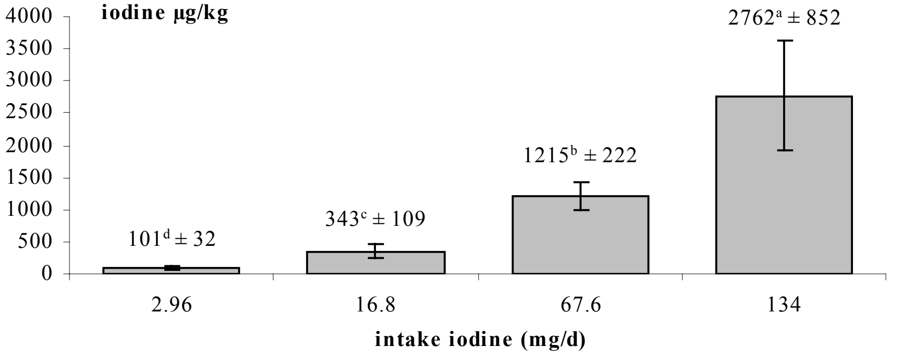

Fig.1: Exp 1 dose-response – milk iodine concentration, mean ± standard deviation (5 cows x 3 day samples). The supplementation was made exclusively by the mineral feed, whereof 150 g/day were offered. In the mineral feed without supplementation 6mg iodine/kg were detected, the further components (maize and grass silage contributed 2 mg iodine per day.

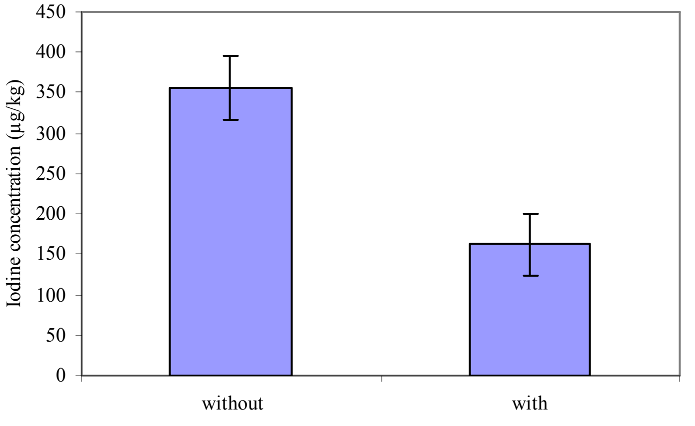

Fig. 2: Iodine concentration of the milk after 5 weeks feeding diets without or with rapeseed meal (mean ± standard deviation), 9 milk samples/group, significant difference by the t-test (P<0.001)

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