Use of *Chlorella* as a carrier of organic-bound iodine in the nutrition of sows

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ABSTRACT: The effect of supplementation with iodine incorporated into biomass of the unicellular alga *Chlorella* on the content of this element in colostrum and milk was investigated in sows of the Large White breed. Experiments were conducted in two elite herds with different levels of iodine supply in basal feed mixtures. On farm A the feed mixture contained 1 549 μg I/kg, on farm B it was 228 μg I/kg. Pregnant sows on both farms were divided into control and experimental group a fortnight before parturition. Control group comprised 8 sows on farm A and 6 sows on farm B. As the sows on both farms received feed rations of 3 kg feed per head/day, iodine uptake of control animals was 4 647 μg I per head/day on farm A and 684 μg I per head/day on farm B. In addition to this supply experimental sows, 9 animals on farm A and 6 animals on farm B, received 450 μg per head/day of iodine bound in *Chlorella* biomass. Total iodine uptake was 5 097 μg per head/day on farm A and 1 134 μg per head/day on farm B. Supplementation also continued in the lactation period when total iodine uptake increased with increasing feed consumption. The supplement of organically bound iodine for experimental sows continued to be 450 μg per head/day. Colostrum samples were taken in both groups on the first two days after parturition while milk samples were taken at the end of the third week of lactation. Iodine concentration in these samples and in feed mixtures was determined spectrophotometrically according to Sandell-Kolthoff's method. Numbers of born and reared piglets, and lactation performance of sows determined by weighing litters on day 21 of piglet life were investigated in individual sows. This litter weight was used to calculate average weight gains of piglets for the period of investigations. The supplementation of *Chlorella*-bound iodine increased the content of this element in colostrum of experimental sows from 365 ± 81 μg/l to 492 ± 122 μg/l on farm A ($P < 0.05$) and from 241 ± 70 μg/l to 391 ± 75 μg/l on farm B ($P < 0.01$). Iodine concentration in milk decreased in all sows, particularly in the animals included in both experimental groups, where it decreased to about half the values detected in colostrum ($P < 0.01$). Lower iodine content in milk of supplemented sows corresponded with their higher lactation performance. Differences in milk production were obvious mainly on farm B, i.e. in sows with low uptake of dietary iodine. The average lactation performance of supplemented sows on this farm was 61.2 ± 7.95 kg/head while in controls it was 54.9 ± 4.22 kg/head. As the number of experimental animals was low, this difference was below the level of statistical significance. Neither was it possible to prove the higher weight gains of piglets found out in both experimental groups on a significance level. No relationship was established between the number of reared piglets and supplementation of organically bound iodine. It can be concluded from the results that the supplementation of iodine bound in *Chlorella* biomass increased its concentration in colostrum of sows with both the low and the high dietary uptake of this element, which proved its good utilisation. A possible positive effect of this supplementation on lactation performance of sows and weight gains of piglets should be verified in further experiments.

Keywords: iodine intake; colostrum; milk; milk production; growth of piglets

Although the importance of iodine for the production of thyroidal hormones, which control the level of metabolism in almost all tissues in the organism, is generally known, this element arouses the attention of specialists in both human and animal nutrition. Concerning farm animals, the attention in recent years has been focused mainly on the level of iodine intake through food, its daily consumption, the way of its supplementation and its interaction with other elements or compounds present in food or drinking water.

There are many studies on this subject including the papers by Herzig and Suchý (1996), Herzig *et al*. (1996), Kroupová *et al*. (1998, 2000), Kursa *et al*. (1998, 2000) and Trávníček *et al*. (1999, 2001). The conclusion of all these studies is that the primary cause of insufficient intake of iodine in food is its shortage in soil and therefore also in plants, especially in highlands and mountains. Another important factor affecting the supply of iodine is the intake of compounds that block the utilization of iodine in the organism. These compounds include plant flavonoids, glucosinolates and nitrates and some other fodder components. The fact that the effect of these so-called goitrogens can be to a large extent compensated by an increased iodine supply is a valuable piece of knowledge. In this context it should be noted that not only the amount but also the form of supplemented iodine is important (Krabačová, 2002).

We tested the possibilities of utilizing *Chlorella* algae for this purpose. Using a special technique of controlled cultivation (Doucha and Lívanský, 2001), we succeeded in obtaining *Chlorella* which contained approximately 1 000 μg I/g of dry matter. By using algae with this iodine concentration we were able to cover the whole or at least a considerable part of the daily need of iodine in experimental animals. The aim of our experiments on sows was to determine the biological availability of iodine in algal biomass. The primary monitored parameter was the concentration of iodine in colostrum and milk of the sows.

Table 1. Content of nutrients in commercial feed mixtures used on farm A and B (calculated per kg of mixture)

	Farm A	Farm B
Metabolisable energy (MJ)	13.3	13.1
Crude protein (g)	179.2	171.7
Fibre (g)	41.0	36.7
Fat (g)	40.9	40.1
Lysine (g)	10.4	8.9
Methionine (g)	3.1	2.8
Threonine (g)	6.6	5.6
Calcium (g)	9.5	8.5
Phosphorus (total) (g)	7.1	6.6
Phosphorus (available) (g)	3.8	3.4
Sodium (g)	2.2	1.9
Zinc (mg)	150.1	158.9
Iron (mg)	165.4	190.3
Copper (mg)	28.6	28.6
Selenium (μg)	240	410
Iodine (analytical values) (μg)	1 549	228
Vitamin A (IU)	12 622	13 623
Vitamin D (IU)	1 801	1 900
Vitamin E (mg)	81.6	75.9
Thiamine (mg)	5.9	6.8
Riboflavin (mg)	5.5	7.9
Vitamin B_6 (mg)	7.1	7.8
Vitamin B_{12} (μg)	31.9	34.6
Pantothenic acid (mg)	25.4	30.5

MATERIAL AND METHODS

Experiments were carried out in two breeding herds on sows of the Large White breed. They started a fortnight before parturition and continued in the nursing period. The sows received feed mixtures for nursing animals. On farm A this mixture (Table 1) contained 1 549 μg I/kg while the iodine content in a similar feed mixture administered on farm B was 228 μg I/kg. Sandell-Kolthoff's spectrophotometric method was used for analyses. To determine iodine content the water extract of ash after alkaline combustion of the sample was used. Selected sows in parity 2 to 4 were divided into control and experimental group on both farms. Control sows, 8 individuals on farm A and 6 individuals on farm B, received iodine only in the above-mentioned feed mixtures. With the daily ration of 3 kg feed/ head it was 4 647 μg I/head/day on farm A and 684 μg I/head/day on farm B. In addition to dietary iodine, experimental sows, i.e. 9 animals on farm A and 6 animals on farm B, were supplemented with 450 μg per head/day of organically *Chlorella*-bound iodine. Their total uptake of iodine was 5 097 μg per head/day on farm A and 1 134 μg per head/day on farm B. The iodine uptake increased with increasing feed consumption in the nursing period while the supplement of organically bound iodine to experimental animals at a dose 450 μg per head/day was on the same level. Colostrum samples were taken from all sows on the first two days after parturition, milk samples were collected at the end of the third week of lactation. Iodine concentrations in the samples were determined by the above-mentioned spectrophotometric method. In sows numbers of born and reared piglets were recorded and their mortality rate was calculated. Lactation performance of sows was determined by weighing the litters on day 21 *post partum*, and these values were used to calculate average weight gains of piglets over the period of investigations.

RESULTS AND DISCUSSION

The analysis of two commercial mixtures showed that the amount of iodine in one of them used on farm B was 228 μg I/kg and did not meet the standard of 300 μg I/kg. Mixture supplied by the other manufacturer to farm A exceeded the standard 5 times, the amount of iodine being 1 549 μg/kg.

These considerable differences between the mixtures were probably caused by different supplementation of iodide salts. In the first mixture, the deviation from the standard iodine level could also have been caused by a long period of storage as the content of inorganic iodine gradually decreases by sublimation. This is a well-known fact in iodised cooking salt. Interestingly, supplementation of iodine as a constituent of the *Chlorella* biomass brought about a considerable increase in the concentration of this element in colostrum in both groups of sows – with insufficient iodine supply and the sows with excessive amounts of iodine in the mixture (Figure 1 and 2). These results point to a high utilisability of iodine bound in the *Chlorella* biomass and are comparable with the results of Krabačová (2002), who used the marine alga *Laminaria digitata* as an iodine supplement for laying hens. When compared with the same supplement of inorganic iodine, the former supplement doubled the amount of iodine in the blood plasma of hens and consequently its amount in yolk. In the case of piglets it should be stressed that a timely and sufficient supply of iodine to the piglets has an extraordinary importance for the development of their cold resistance. Thyroidal hormones, which stimulate the increase of heat production in the postnatal period, depend directly on iodine supply.

The level of iodine in sow milk was lower than the amount in colostrum. On farm A this difference was found in both experimental and control animals (Figure 1), whereas on farm B a significant colostrum/milk difference was determined only in the experimental sows (Figure 2). This result corresponds with the measurements by Aumont *et al*. (1989), who found 1.5 to 6.7-fold higher amounts of iodine in colostrum compared to its amount in milk depending on the level of iodine supplementation to pregnant ewes.

Somewhat surprising was the finding that the supplementation with the high-iodine alga did not result in increased iodine concentration in the sows' milk but in fact had a slightly opposite effect. This was attributed to the fact that the sows consumed large amounts of feed at the end of the third week after delivery so that the daily supplement of 450 μg of algal iodine was negligible compared to its dietary intake. The higher milk production in sows of farm B also contributed to this result (Figure 3).

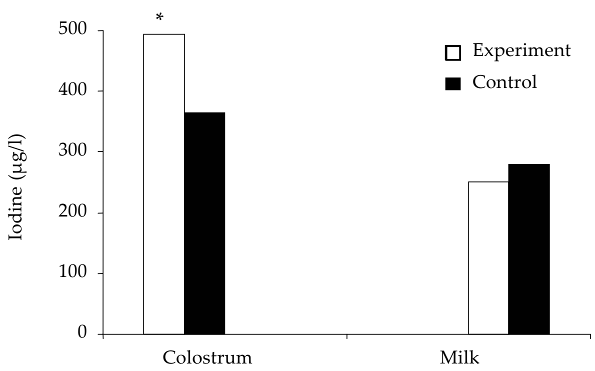

Figure 1. Amount of iodine in colostrum and milk of experimental sows – farm A (*$P < 0.05$)

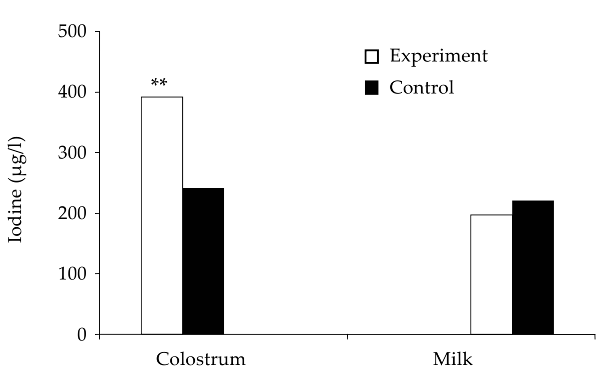

Figure 2. Amount of iodine in colostrum and milk of experimental sows – farm B (**$P < 0.01$)

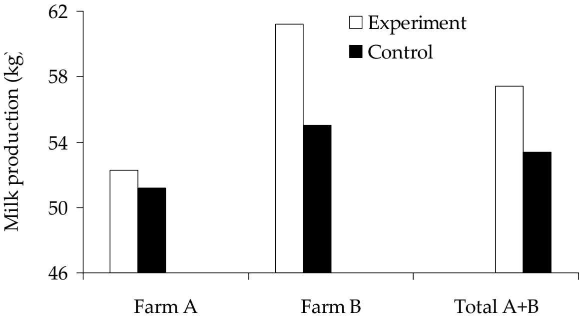

Figure 3. Mean milk production by the sows (litter weight at 21 days of age

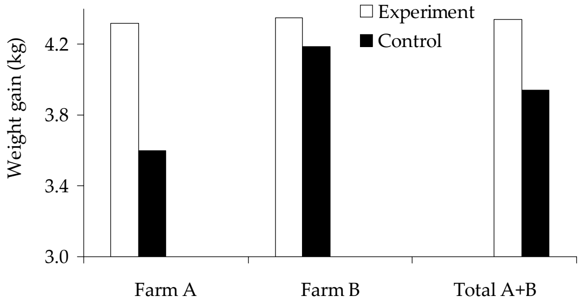

Figure 4. Mean live weight gains of piglets from birth to 21 days of age

Table 2. Mean numbers of born and successfully reared piglets

Farm	Group	Numbers of piglets		Mortality (%)
		born	successfully reared	
A	experimental	10.2	9.0	11.7
	control	10.5	10.3	1.9
B	experimental	12.8	10.6	17.2
	control	11.1	9.8	2.7
Total A + B	experimental	11.5	9.8	14.3
	control	10.8	10.0	1.7

The weight gains of piglets developed in accordance with the milk production of sows (Figure 4). Due to the low number of animals in the experiment the rather high weight differences found between the experimental and the control litters on farm A did not reach statistical significance. The numbers of successfully reared piglets did not confirm any significant influence of algal iodine supplementation on this parameter (Table 2). In fact, farm B showed a higher mortality of piglets as a result of several extremely large litters in some of the experimental sows (2 × 17 piglets, 1 × 14 piglets) with a subsequent increased postnatal loss of piglets with lower birth weight.

CONCLUSIONS

Supplement of iodine bound in *Chlorella* biomass in a dose of 450 μg per sow and day for 14 days before farrowing and during suckling significantly increased the amount of this element in colostrum. The increase was found not only in the group with low inorganic iodine amounts in the commercial mixture but also in the group fed mixtures containing amounts of inorganic iodine 5 times higher than the standard. These results documented a high biological availability of iodine bound in the *Chlorella* biomass.

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Received: 03–05–05
Accepted after corrections: 03–12–17

ABSTRAKT

Využití řasy *Chlorella* jako nosiče organicky vázaného jódu ve výživě prasnic

Na prasnicích plemene bílé ušlechtilé jsme sledovali vliv přídavku jódu zabudovaného do biomasy jednobuněčné řasy *Chlorella* na obsah tohoto prvku v mlezivu a mléku. Pokusy proběhly ve dvou šlechtitelských chovech s různou úrovní dotace jódu v základních krmných směsích. V chovu A krmná směs obsahovala 1 549 μg I/kg, v chovu B bylo zjištěno 228 μg I/kg. Březí prasnice v obou chovech byly 14 dnů před porodem rozděleny do kontrolní a pokusné skupiny. Do kontrolní skupiny bylo v chovu A zařazeno osm prasnic, v chovu B šest prasnic. Při krmné dávce v obou chovech 3 kg směsi/kus/den byl příjem jódu kontrolních zvířat 4 647 μg /kus/den v chovu A a 684 μg na kus a den v chovu B. Pokusné prasnice, v chovu A devět kusů a v chovu B šest kusů, kromě této dotace dostávaly 450 μg/kus/den jódu vázaného v biomase řasy *Chlorella*. Celkový příjem jódu tak u nich činil 5 097 μg /kus/den v chovu A a 1 134 μg/kus/den v chovu B. Suplementace pokračovala i v době laktace, kdy celkový příjem jódu se zvyšoval s růstem příjmu krmiva. Přídavek organicky vázaného jódu pokusným prasnicím činil i nadále 450 μg na kus a den. V prvých dvou dnech po porodu byly od obou skupin odebírány vzorky mleziva a na konci třetího týdne laktace vzorky mléka. V těchto vzorcích, a stejně tak i v krmných směsích, byla spektrofotometricky stanovena koncentrace jódu podle Sandell-Kolthoffa. U jednotlivých prasnic byly sledovány počty narozených i odchovaných selat a dále mléčnost prasnic stanovená zvážením vrhů 21. dne života selat. Z tohoto údaje byly vypočítány i průměrné přírůstky selat za sledované období. Přídavek jódu vázaného v řase *Chlorella* zvyšoval obsah tohoto prvku v mlezivu pokusných prasnic ze 365 ± 81μg/l na 492 ± 122 μg/l v chovu A ($P < 0,05$) a z 241 ± 70 μg/l na 391 ± 75 μg/l v chovu B ($P < 0,01$). Koncentrace jódu v mléku poklesla u všech prasnic, zejména však u jedinců v obou pokusných skupinách. U nich se snížila přibližně na polovinu hodnot nalezených v mlezivu ($P < 0,01$). Nižší obsah jódu v mléku suplementovaných prasnic korespondoval s jejich vyšší mléčností. Rozdíly v mléčné produkci byly patrné zejména v chovu B, tj. u prasnic s nízkým příjmem jódu v základní krmné směsi. Zde průměrná mléčnost suplementovaných prasnic dosáhla 61,2 ± 7,95 kg/kus, zatímco u kontrol jsme zjistili 54,9 ± 4,22 kg/kus. Tato diference se však pro malý počet pokusných jedinců udržovala pod hranicí statistické významnosti. Stejně tak nebylo možné statisticky prokázat vyšší přírůstky selat nalezené v obou pokusných skupinách. Mezi počtem odchovaných selat a suplementací organicky vázaného jódu vztah nalezen nebyl. Přídavek jódu vázaného v biomase řasy *Chlorella* zvýšil jeho koncentraci v mlezivu jak u prasnic s nízkým, tak vysokým příjmem tohoto prvku v krmných směsích, což svědčí o jeho dobré využitelnosti. Možný pozitivní vliv této suplementace na mléčnost prasnic a přírůstky selat bude nutné ověřit dalšími experimenty.

Klíčová slova: příjem jódu; mlezivo; mléko; mléčnost; růst selat

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