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The effects of iodised salt licks and teat dipping on the iodine content of cow's milk and blood plasma

Wpływ jodowanych lizawek solnych i dippingu strzyków na zawartość jodu w mleku i osoczu/osoczu krwi krów

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Abstract

Introduction: Milk has been identified as the ideal carrier of iodine in the human diet. The iodine concentration in cow's milk depends on the iodine intake in the animal's daily rations.

Materials and methods: The first experiment, which lasted for 90 days, investigated the effectiveness of salt licks containing 0 (control group), 150, and 300 mg I/kg (experimental groups) and the effect on the iodine content of cow's milk and blood plasma. The second experiment determined the effect of udder disinfection and iodine teat dipping with iodine disinfectant (experimental group) compared to chlorine dip (control group) on the iodine content of milk and blood plasma. Milk iodine and blood plasma concentrations were measured using the Sandell-Kolthoff method modified by the Bobek and Kołczak procedure.

Result: Salt licks containing 150 and 300 mg I/kg increased iodine intake by 7.5 and 15.0 mg I/day, respectively. Average iodine intake in the control group was 6.23 mg I/day, and 13.68 and 21.10 mg I/day in the experimental groups, respectively. There were no significant differences in the average cows' milk yield, which averaged 21.0 ± 1.1 kg/day. **Average** milk iodine content was 53.8 μg/1000 mL (control group), 65.0 and 84.7 μg/1000 mL (experimental groups). Average plasma iodine content tended to increase in the experimental groups, but the differences between the groups were not significant. In the second experiment iodine udder disinfection and teat dipping increased average milk iodine content from 44.0 ± 1.6 to 59.3 ± 2.3 μg/1000 mL. Average plasma iodine content increased only slightly, with a non-significant difference between the control and experimental groups.

Conclusion: The iodine content of salt licks at 150 and 300 mg I/kg makes it possible to obtain from 65 to 85 μg I/1000 mL of cow's milk. Pre-milking udder hygiene and post-milking iodine teat dipping additionally increase the iodine content of milk by around 15 μg I/1000 mL milk, i.e. an increase of 35% in relation to cows from the control group. **(Endokrynol Pol 2015; 66 (3): 244–250)**

Key words: *iodine; salt licks; udder dipping; milk; blood serum; iodine content*

Streszczenie

Wstęp: Wykazano, że mleko jest bardzo dobrym nośnikiem jodu dla człowieka. Zawartość jodu w mleku zależy od pobrania jodu w dawce pokarmowej przez krowy.

Materiał i metody: W doświadczeniu pierwszym, w czasie 90 dni badano efektywność lizawek solnych zawierających 0 mg I/kg (grupa kontrolna), 150 i 300 mg I/kg (grupy doświadczalne) oraz wpływ na zawartość jodu w mleku i osoczu krwi. W doświadczeniu drugim określano efektywność dezynfekcji gruczołu mlekowego i strzyków z użyciem preparatów jodowych (grupy doświadczalne) w porównaniu do preparatu chloranowego (grupa kontrolna). Badano zawartość jodu w mleku i osoczu krwi krów. Stężenie jodu w mleku i osoczu krwi oznaczano metodą Sandell-Kolthoffa w modyfikacji Bobka i Kołczaka.

Wyniki: Lizawki solne zawierające 150 i 300 mg I/kg zwiększyły pobranie jodu od 7,5 do 15,0 mg/dobę. Średnie pobranie jodu w grupie kontrolnej wynosiło 6,23 mg/dobę oraz 13,68 i 21,10 mg I/dobę w grupach doświadczalnych. Nie stwierdzono znamiennych różnic w średniej wydajności mlecznej, która wynosiła 21,0 ± 1,1 kg/dobę. Średnia zawartość jodu w mleku wynosiła 53,8 μg/1000 ml (grupa kontrolna), 65,0 i 84,7 μg/1000 ml (grupy doświadczalne). Średnia zawartość jodu w osoczu krwi wykazywała tendencję rosnącą w grupach doświadczalnych, ale różnice pomiędzy grupami były nie znamienne. W doświadczeniu drugim, dezynfekcja gruczołu mlekowego preparatem jodowym i stosowanie dippingu strzyków zwiększyło średni poziom jodu w mleku z 44,0 ± 1,6 do 59,3 ± 2,3 μg/1000 mL. Średnia zawartość jodu w osoczu krwi zwiększyła się nieznacznie, a różnice pomiędzy grupami były nie istotne za cały okres doświadczenia.

Wnioski: Zawartość jodu w lizawkach solnych na poziomie 150 i 300 mg I/kg zwiększa zawartość jodu w mleku krów z 65 do 85 μg/1000 mL. Stosowanie higieny gruczołu mlekowego preparatem jodowym przed dojem i dippingu strzyków po doju zwiększa zawartość jodu o około 15 μg/1000 mL mleka, czyli o 35% w stosunku do grupy kontrolnej. **(Endokrynol Pol 2015; 66 (3): 244–250)**

Słowa kluczowe: *jod; lizawki solne; dipping strzyków; mleko; osocze krwi; zawartość jodu*

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Introduction

In mammalian organisms, iodine plays a key role in regulating their metabolism. It is a component of thyroid hormones thyroxine (T_4) and triiodothyronine (T_3). In the thyroid, it is bound and stored in the form of a protein-iodine complex known as thyroglobulin [1, 2]. Iodine in milk plays a crucial role as an important source of iodine in the diet of humans, including children. Many countries, including Poland, prevent iodine deficiency disorders in humans by iodisation of table salt [3, 4]. Overconsumption of salt in many products, including bread, meat, and table salt, contributes to arterial hypertension and causes cardiovascular diseases in humans [5, 6]. The need to reduce dietary intake of salt, and consequently iodine, forces us to look for alternative sources of iodine. Milk has been identified as the ideal carrier of iodine in the human diet. The iodine content of cow's milk depends on the level of iodine supply in the diet of cows and, to a lesser extent, on the chemical form of iodine [7–9]. The results of 17 experiments showed that percentages of radioiodine intake from milk averaged 8% and rarely exceeded 10% [10]. The iodine requirements of cows was estimated for 100-600 μg iodine contain in one kilo of dry matter in the daily ration [11, 12], which means the intake by the cow is 15 mg iodine/day. Animal Feeding Stuff Legislation of the EU permits the use of 5 mg I/kg in commercial feed for dairy cows, which means intake of approximately 30–40 mg I/day with 30 kg of milk per day [13]. Dairy cows receive iodine in the form of potassium iodide or iodate, which are found in mineral-vitamin mixtures added to mixed cereals. It is estimated that only 20–25% of the Polish cow population are fed commercial feed mixtures containing iodine. The rest of the cow population are fed mineral feeds or salt licks containing iodine. As a result of which iodine level in milk varies widely from approximately 70 to 240 μg I/1000 mL of milk. A monitoring study of consumer milk in Poland, conducted in 2007–2008, showed an average of 100.4 μg I/1000 mL in summer and 146.8 μg I/1000 mL in winter. Regional variations in the iodine content of consumer milk were ± 38% in summer and ± 19% in winter [14]. A monitoring study of consumer milk in Poland, conducted in 2011–2012, showed an average of 143.2 μg I/1000 mL in summer and 182.4 μg I/1000 mL in winter [15]. A feed additive that contains iodine is the salt lick (blocks), which are the main source of sodium and chlorine for cows. The sodium requirement of cows is around 21 g Na/day, and intake of salt licks was estimated to be 35–65 g/day [16–17]. A second source of iodine for cows is udder teat disinfectants and sprays that close up the teat channel orifice after milking. These preparations are used in cow herds to prevent bacterial infections that cause mastitis. A considerable proportion of commercially available udder hygiene products contain 3–5 g/kg of iodine. Iodine applied to the udder surface and teat channel orifice is absorbed into the blood through skin integuments and can increase the iodine content of milk. The available information on this subject is inconsistent and covers a long period of time [18–24]. It was assumed that giving cows iodine-fortified salt licks as well as teat dipping with iodine would increase milk iodine content.

The objective of the present study was to determine the effect of increasing milk and blood iodine levels in cows by giving salt licks containing different amounts of iodine (0; 150; 300 mg I/kg), and by applying a teat disinfectant with 3 g/kg of iodine and without iodine.

Material and methods

Experiment 1

Sixty mid-lactating Polish Holstein-Friesian cows with an average milk yield of 21.0 ± 1.0 kg/day and 602 ± 11 kg of body weight were randomly assigned to three groups with 20 animals per group. Cows were fed based on IZ-INRA feeding standards [25]. The ration was two-thirds roughage and one-third feed mixture and ensiled high-moisture maize grain (Table I). Dry matter intake was 22.0 ± 1.1 kg/day. The diet was given as a total mixed ration (TMR) while the feed mixture was given via a computerised feeding sta-

Table I. *Ingredients and nutrient content in the daily ration (Exp. 1)*

Tabela I. *Komponenty i składniki dawki pokarmowej (Dośw. 1)*

Item	Dry matter kg/day	%
Diet components		
Maize silage	8.0	37.4
Alfalfa silage, first cut	1.8	8.4
Grass silage, first cut	1.4	6.5
Brewery malt residues	1.0	5.6
High moisture maize grain, ensiled	1.2	4.7
Solvent meal, rape	1.8	8.4
Soybean meal	0.9	4.2
Feed concentrate[1]	5.3	24.8
Nutritive value		
Dry matter [kg/day]	21.4	
NEL [MJ/**day**][2]	80.93	
IDP [g/**day**] [2-3]	1350.2	

[1]with mineral mixture without iodine; [2]NEL net energy for lactation, data calculated from chemical composition by WINPASZ software; [3]IDP — intestine digestible protein [46]

tion. Feed dry matter and feed intake were recorded. Iodine content of the basal diet was 0.25 mg/kg of dry matter. The feed mixture contained no iodine supplement. The experiment was divided into three 30-day periods. In addition to the diet, cows from different groups received salt licks containing different amounts of iodine: no iodine (group I), 150 mg I/kg (group II), and 300 mg I/kg (group III). Salt licks were manufactured at the Kłodawa Salt Mine with supplemental potassium iodide (KI). Cows from different groups had free access to salt licks with different iodine content, roughage, feed mixture, and water. Cows were milked twice daily in a milking parlour. Udders were disinfected and teats were dipped with an iodine-free disinfectant. The milk yield of the cows was determined at the beginning of the experiment and on the last day of each 30-day period (Mini F.V Milkometer, TruTest Distributors Ltd., New Zealand). Feed intake was determined and samples of feed, and milk and blood were collected for chemical analysis on the last day of each period. Milk was preserved with Gropol (2-bromo-2-nitro-1,3-propandiol) and frozen. Blood samples (10 mL) were collected from the tail vein into heparinised tubes, centrifuged to separate plasma, and frozen until analysis of iodine content. Milk was sampled during the morning and evening milking.

Experiment 2

Twenty-eight Polish Holstein-Friesian cows were randomly divided into 2 groups with 14 animals per group. Cows were between the 103rd and 121st days of lactation and their body weight averaged 609 ± 17 kg. Animals were fed based on IZ-INRA Feeding Standards [25] and received the same rations as in experiment 1. Feed dry matter and feed intake were recorded. Iodine content of the basal diet was 0.25 mg/kg of dry matter. The feed mixture contained no iodine supplement. The experiment was divided into two periods: 30-day pretreatment and 30-day treatment. The pretreatment period served to halt the action of the disinfectant used before the start of the experiment. Cows from both groups received salt licks containing 100 mg I/kg. Prior to milking, the udder was moistened with iodine-free (control group) and iodine disinfectants (experimental group), and wiped dry with paper towels. After milking, teats were immersed to a depth of 3 cm in an iodine-free disinfecting solution (control group) and in a solution containing 3 g/kg of iodine (experimental group). The milk yield of the cows was recorded at the beginning of the experiment and on the last day of each 30-day period. Milk samples from the morning and evening milking were collected on the last three days of each period. Milk was preserved with Gropol (2-bromo-2-nitro-1,3-propandiol) and frozen. Cows from different groups had free access to salt licks. Feed intake was determined and samples of feed and blood were collected for chemical analysis on the last day of each period. Blood was drawn from the tail vein into heparinised tubes, centrifuged to separate plasma, and frozen until analysis of iodine content.

Nutrient content of the feeds was determined using AOAC [26] reference methods. The iodine content of milk and blood plasma was determined by the colorimetric method of Sandell and Kolthoff [27] and modified by Bobek and Kołczak [28].

Statistical analysis was performed by analysis of variance using Duncan's test (experiment 1) and Student's t-test (experiment 2) in accordance with SAS procedures (2001) [29].

Results

Experiment 1

Dry matter intake by the cows was equalised and showed no significant differences (Table II). No differences were found between the groups in iodine intake from the ration and from the feed mixture dispensed from automatic feed boxes. Licks that contained 150 and 300 mg I/kg ensured iodine intakes from 7.5 to 15.0 mg I/day. Total iodine intake by the cows ranged from around 6.0 to 21.1 mg I/day. No significant differences were observed in cows' milk yield, which averaged 21.0 ± 1.4 kg/day for 90 days of the experiment. There were no significant differences in the amount of milk drawn during 60 days of the experiment. Giving salt licks containing 150 mg I/kg increased milk iodine content by 11.2 μg/1000 mL. Free access of the cows to salt licks containing 300 mg I/kg increased milk iodine content by 30.9 μg/1000 mL compared to the control group. Differences between the groups were highly significant ($P \leq 0.01$). Plasma iodine content tended to increase in the experimental groups, although no significant differences were found between the groups.

Experiment 2

This experiment used cows in similar lactation stages, similar body weight, and daily ration (Table III). No differences were found in dry matter intake between the groups. The experiment started with a milk yield of 36.5 kg/day and ended after 60 days when the milk yield was around 29.0 kg/day. In both 30-day periods, no significant differences were noted in the milk yield of the cows. Iodine udder disinfection and teat dipping increased milk iodine content by 15.3 μg/1000 mL in relation to the control group ($P \leq 0.01$). Plasma iodine content increased slightly, but the difference between the control and experimental groups was not significant.

Table II. *Cow's body weight, feed and iodine intake, and iodine content in milk and blood serum (Exp. 1)*
Tabela II. *Masa ciała krów, pobranie paszy i jodu oraz zawartość jodu w mleku i osoczu krwi (Dośw. 1)*

Item	Iodine content in salt licks [mg/kg]			SEM
	0	150	300	
Cow's body weight [kg]				
Start	612	589	605	12.5
Finish	627	604	619	7.9
Total increase	+ 15	+ 15	+ 14	0.91
Increase per day	+ 0.17	+ 0.17	+ 0.16	0.23
Feed intake (DM [kg/day])[1]				
TMR ration (feed table)	20.6	19.7	19.9	1.33
Feeding stuffs (feed station)	2.0	1.8	1.9	0.27
Total dry matter	22.6	21.5	21.8	0.17
Iodine intake [mg/day]				
Daily ration with water (TMR)[2]	4.64	4.44	4.50	4.13
Feeding stuffs from feed station	1.59	1.74	1.60	**1.57**
Salt lick[3]	0.00	7.50	15.00	**3.01**
Total iodine intake	6.23^{Cc}	13.68^{Bb}	21.10^{Aa}	**2.65**
Iodine content in milk [µg/L]				
30 day (1st period)	**59.7^{ABa}**	**57.7^{Aa}**	**87.3^{Bb}**	2.42
60 day (2nd period)	**53.8^{Aa}**	**68.3^{ABab}**	**78.7^{Bb}**	**0.425**
90 day (3rd period)	**47.9^{Aa}**	**69.1^{ABab}**	**88.1^{Bb}**	**0.301**
Total iodine	53.8^{Aa}	65.0^{ABab}	84.7^{Bb}	**0.522**
Iodine content in blood serum [µg/100 mL]				
30 day (1st period)	**6.13**	**5.83**	**5.72**	**0.149**
60 day (2nd period)	**6.83^{ABab}**	**5.38^{Aa}**	**7.87^{Bb}**	0.58
90 day (3rd period)	**4.70**	**6.14**	**4.81**	64
Total iodine	**5.95**	**5.79**	**6.12**	
Average milk yield [kg/day]	21.2	21.0	20.7	
Milk production per experiment and cow [kg]	1905	1890	1863	

[1]Iodine content in drinking water was estimated to be 3 µg/L, water consumption was 45 l/day; [2]Iodine intake in salt licks was calculated from proximate intake of salts as 50 g/day; [3]DM — dry matter; TMR — total mixed ration; $^{A, B, C}$ — values in the same rows with different letters differ significantly ($P \leq 0.01$); $^{a, b, c}$ — values in the same rows with different letters differ significantly ($P \leq 0.05$)

Table III. *Milk yield, iodine content in milk and blood serum after teat iodine dipping (Exp. 2)*
Tabela III. *Wydajność mleka, zawartość jodu w mleku i osoczu krwi po dipingu strzyków jodem (Dośw. 2)*

Item	Dipping without iodine	Dipping with iodine	P ≥ F	F
Lactation day	121 ± 39^{Aa}	103 ± 45^{Bb}	0.1849	1.82
Lactation number	2.3 ± 1.4	2.0 ± 0.9	0.4319	0.63
Cow's body weight	611	607	0.5466	0.47
Dry matter intake [kg/day]	24.5	23.9	0.3987	0.31
Milk yield [kg/day]				
Start of experiment	36.5 ± 5.5	36.5 ± 5.3	0.9954	0.00
30th day	31.8 ± 4.2	31.0 ± 4.9	0.5825	0.31
60th day	29.2 ± 5.1	28.7 ± 6.0	0.7883	0.07
Iodine intake [mg/day]	11.44	11.44		
Iodine content in milk [µg/1000 mL]	44.0 ± 1.6Bb	59.3 ± 2.3Aa	0.0018	11.8
Iodine content in blood serum [µg/100 mL]	4.9 ± 1.44	5.4 ± 1.31	0.3349	1.0

Abbreviation se table II

Discussion

Feed mixtures are the main source of iodine for dairy cows. Feed legislation permits feeding animals with potassium iodide (KI), sodium iodide (NaI), calcium iodate anhydrous ($Ca[IO_3]_2$, and calcium iodate hexahydrate ($Ca[IO_3]_2 \cdot 6H_2O$) [30]. These substances are given to animals, including cows, in the form of vitamin-mineral mixtures. The act sets out the maximum feed mixture iodine content of 5 mg I/kg [13]. This means that cows yielding 30 kg milk/day and consuming around 6–7 kg of feed mixture have an intake of 30-35 mg I/day. Considering the intake of iodine from roughage, water, and air (3–5 mg/day), this translates into 33–40 mg I/day. Earlier findings suggest that this level of iodine intake results in a milk iodine content of 150–180 μg/L [31–32, 33]. The overall mixed feed production in Poland is around 9 000 000 tons, of which less than 1 000 000 tons are intended for cattle, with a population of 2 551 000 cows [34]. Commercially manufactured feeds, formulated to provide adequate nutrients and iodine, are given to around 100 000 cows producing an average of 8 000–10 000 kg milk/Lactation. It is estimated that they each consume 1.5–1.8 tons of mixed feeds per year. Around 80% of dairy cows receive no feed mixtures formulated to provide adequate amounts of protein, energy, and minerals, including iodine. Many milk producers feed cows with their own cereals, legume seeds, as well as rapeseed feeds and soybean meal supplemented with mineral mixtures that contain iodine or not. Currently it is not possible to determine the proportion of cows that receive commercial feed mixtures with iodine and the proportion of cows that receive farm-produced mixed cereal feeds. It is not possible to balance cow diets for iodine supply and intake.

Another source of iodine for cows are salt licks made from mined salt, ground and unevaporated, which is formed into 10 kg cubes in high-pressure press machines, in amounts of approximately 1 000 000 per year. Around 30% is exported and the rest is fed in Poland. The Ministry of Agriculture and Rural Development allowed the use of 100 mg I/kg in salt licks. Research on the use of salt licks by cows showed that they consume from 35 to 65 g/day depending on temperature and thus season of the year [8, 14, 16]. Iodine intake from salt licks averages 5 mg I/day/cow and can affect milk iodine levels in cows that receive no commercial feed mixtures. Research has shown that in order to increase iodine intake by the cows receiving no feed mixtures with iodine, iodine concentration in salt licks should be increased to 150 or even 300 mg I/kg. The results of our study (experiment 1) demonstrated that this increases iodine intake to around 16.5 and 24.0 mg/day and milk iodine concentration to 65.0 and 85.0 μg/1000 mL of milk, respectively. In countries where production and consumption of feed mixtures by cows is 1.5–2.0 tons//Lactation, salt licks most often contain no supplemental iodine. The feed iodine content of 10 mg/kg, especially in the second half of lactation, caused milk iodine concentration to exceed 1000–2000 μg/1000 mL, which is 3 to 4 times the daily human iodine requirement [35, 36]. In an effort to reduce the excessive iodine content of milk in the European Union countries that use considerable amounts of compound feeds containing iodine, the EFSA [13] recommended reducing the maximum levels of iodine in cow nutrition from 10 to 5 mg I/kg of feed. The results of our study showed that milk iodine content in cows supplemented with no iodine salt licks is around 50 μg/1000 mL, which is consistent with our earlier findings and the results of early iodine monitoring in Poland [37, 38].

Another factor that can affect cow's milk iodine levels is the hygienic practice of iodine dipping, in which teats are dipped in disinfectant. Teat disinfectants most often contain 3–5 g iodine/kg. They are used for udder cleaning before milking and to seal the teat channel orifice after milking. Teat dipping prevents pathogenic bacteria from entering the teat channel and reduces inflammation in one or more quarters of the udder. Iodine found in the disinfectants penetrates the skin to reach blood vessels and can also increase the iodine content of milk. While teat dipping is not common in Poland, it is used in all large cow farms producing market milk. Iodine dipping research has brought inconclusive results, showing milk iodine content to increase within wide limits depending on iodine concentration in the disinfectants and on pre- and post-milking practices. In a review paper Flachowsky et al. [23] report, citing 12 studies, that iodine dipping increases milk iodine content by an average of 68 (35–150) μg/1000 mL milk. The use of teat dips containing 3 g I/kg [23] and 4 g I/kg [24] caused milk iodine content to increase from 33 to 54 μg/1000 mL milk. Iodine dipping has received a great deal of attention in the past, especially in American and German studies [19, 23, 39, 40]. In an earlier study, iodine teat dipping increased the cow's milk iodine content by 80–100 μg/1000 L (Conrad and Hemken, 1978) [22]. However, recent research shows that pre-milking udder disinfection with iodine dips containing 5 g I/kg has little effect on milk iodine levels, provided that the dip is well tried and of good quality, and the teats are thoroughly wiped prior to attachment of the milking clusters [20]. The same authors believe that in order to obtain iodine levels below 400 μg/1000 L milk, the ration should contain less than 1 mg I/kg daily ration dry matter for cows, which corresponds to NRC [41] recommendations of 0.5 mg I/kg of ration dry matter. These figures are more restrictive than European Union recommendations. This may arise from the fact that iodine-based disinfectants are commonly used by US milk producers.

Iodine disinfectants are also used to disinfect milking equipment, milk pipelines, and hoses, as well as milk tanks and tankers, where iodine residues may enter milk during the next milking. The present results showed that in control groups receiving no dietary iodine, where iodine-free dips were used, milk iodine content did not exceed 45.0 μg/1000 mL. In the experimental group where an iodine dip containing 3 g I/kg was used, milk iodine level increased to 65 μg/1000 mL and was 35% higher than in the control group. Our results generally fall within the values cited by Flachowsky et al. [23]. Milk iodine content can also be increased by iodine disinfection of milking equipment, pipelines, rubber hoses, milk tanker trucks and milk tanks. It is estimated that 80–90% of iodine in milk is inorganic and dissolved in the liquid fraction [42]. Iodophor-derived iodine in milk is in iodate form [43]. Iodine preparations are made by dissolving iodine in a surface-active agent, which adheres to the walls of hoses in milk pipelines, thus increasing its disinfection power [44].

The effects of dietary iodine and the use of iodine teat dipping on blood plasma were not investigated in any the studies cited above. Earlier studies by German authors (1997–2003) showed, after analysis of 3334 blood serum samples, the average iodine content to increase from 5.1 to 12.0 μg/100 mL in response to iodine disinfectants [45]. The results of earlier Polish studies fell within the lower range of these figures [10–13]. In the presented results of studies, plasma iodine levels in cows receiving salt licks with different iodine content showed an upward trend, although the differences between the groups, with an average content of 5.9 μg/100 mL, were not significant. Also udder hygiene practices and the use of iodine teat dipping increased the plasma iodine content, with non-significant differences between the groups. Plasma iodine content values were within the lower range of values reported by [45] based on monitoring of blood plasma.

It is concluded that considering the lack of iodine in farm-produced feed mixtures, the iodine content of salt licks at 150 and 300 mg I/kg makes it possible to obtain from 65 to 85 μg I/1000 mL of cow's milk. Pre-milking udder hygiene and post-milking iodine teat dipping additionally increase the iodine content of milk by around 15 μg I/1000 mL milk, i.e. by 35% in relation to cows from the control group, where iodine-free dipping was used and cows from both groups received salt licks containing 100 mg I/kg and were given no iodine in feed mixtures.

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