EFFECT OF HIGH IODINE INTAKE ON SELECTED PARAMETERS OF IMMUNITY IN SHEEP

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Abstract

The study aimed at defining the immunity risks connected with high iodine supplementation in ewes and their lambs. The feed ration for control group (C) of ewes (n=6) contained 3.1 mg of iodine per kilogram of dietary dry matter and for experimental group (E) of ewes (n=6) 5.1 mg of iodine per kilogram of dietary dry matter. The animals were fed the diets for 8 months. Parallely with different iodine supplementation, some immunological parameters (percentage of γ-globulins, concentration of immunoglobulin G, and white blood cell count) were examined in ewes and their lambs. The difference in the average concentration of immunoglobulin G between the ewes of group C and E was not significant during the experiment. A significant decrease (P<0.01) in the concentration of immunoglobulin G from 19.6 mg/mL before the experiment to 9.8 mg/mL on day 60 of the experiment was demonstrated in the ewes of group E. The average percentage of γ-globulins in the whole period after parturition was lower in the ewes of group E than in group C. The concentration of immunoglobulin G and the percentage of γ-globulins in lambs from dams in group E was continually lower (P<0.01) for the entire period of 1-30 d and demonstrated immunological risks of the excessive intake of iodine. The obtained results document a dangerous influence of high iodine intake on immunity in the prenatal period in ewes and mainly in the postnatal period in their lambs.

Key words: ewes, lambs, immunoglobulin G, γ-globulins, leukocytes

Iodine is an essential component of the thyroid hormones thyroxine (T₄) and triiodothyronine (T₃), which are necessary for adequate growth and development of animals (4). Iodine deficiency, and also its excess have an undesirable influence on the health of animals and optimum production (15). According to the National Research Council (16), the recommended daily intake of iodine for beef cattle is 0.3-0.6 mg/kg of dry matter (DM). The maximum permitted limit of iodine concentration is 5 mg/kg of 88% dietary DM according to EU Commission (12). The interactions between nutritional status, immunology, and disease resistance are extremely complex (21). Excess of iodine can cause elevated temperature, dry coughing, and runny nose and eyes (18).

An increased attention has been paid to the influence of high iodine intake on immune parameters in the last decade (11). According to Boland et al. (5, 6) and Rose et al. (19) at high I intake in pregnant ewes, a linear decrease in IgG concentration occurs in their lambs as influenced by a reduction in its intestinal resorption from colostrum. It is an important finding because lambs are born agammaglobulinemic and are therefore dependent on maternal colostrum to supply immunoglobulins for disease protection in their early life (8). Adequate immunoglobulin absorption is critical for the subsequent health of the neonates, and a deficiency is associated with an increased incidence of pneumonia, septicaemia, infections of the navel, and diarrhoea, all of which lead to increased mortality (9).

The objective of this study was to determine whether the long-term application of high iodine doses (above the upper limit of the permitted standard of 5 mg/kg of 88% dietary DM) would influence chosen immune parameters in ewes and their newborn lambs.

Material and Methods

Animals. The study was carried out on a Demonstration Farm of the Faculty of Agriculture (University of South Bohemia in České Budějovice, Czech Republic). The ewes of the Šumava breed in the 5th lactation, weighing 53-60 kg, were used in the experiment. They were kept under the same environmental conditions before and during the experiment. After birth the lambs were kept with their mothers and sucked their milk (they received only milk until the end of the experiment). In the experimental period (from 1-2 months of gravidity to 60 d after parturition) the feed ration for the particular groups differed only in iodine content in the mineral...
supplement. The formulation of feed ration during the entire period was as follows: 1,500 g of meadow hay, 240 g of lucerne granules, 270 g of oat groats, and 9 g of mineral supplement. Water was supplied ad libitum to all sheep.

The influence of long-term iodine intake on immune parameters was studied for eight months in a control group (C) of ewes (n=6) and in an experimental group (E) of ewes (n=6), and in their newborn lambs (seven lambs from dams in group C and six lambs from dams in group E). The daily intake of iodine in the group C was 3.1 mg/kg of dietary dry matter (DM) and in the group E - 5.1 mg/kg DM. Iodine in the feed mixture was in the form of calcium iodate. The daily intake of iodine in the group C was 3.1 mg/kg of dietary dry matter (DM) and in the group E - 5.1 mg/kg DM. Iodine in the feed mixture was in the form of calcium iodate. Table 2 shows the total iodine intake in the bulky and concentrate component of feed ration and mineral supplement in groups C and E.

**Analysis of blood samples.** Blood samples collected from 12 ewes and 13 lambs between 7.00 and 9.00 a.m. from the v. jugularis into tubes were centrifuged (at 3,000 r/min for 10 min). The blood serum was used to determine the concentration of IgG in mg/mL (ELISA, ELISA Development, s.r.o.) and the percentage of γ-globulins (electrophoresis – Sebia Electrophorèse). At the same time, the blood of ewes and lambs was collected into tubes to determine the white blood cell count (WBC). Data was analysed using the Statistica 6.0 software (ANOVA test, Tukey’s test). The values P<0.05 and lower were considered as significant. Results are expressed in mean values ± standard deviations.

**Results**

Before the start of the experiment, the average concentration of IgG in blood serum (mg/mL), average percentage of γ-globulins in blood serum, and average WBC count (G/L) did not show any significant differences between the ewes of group C and E (Table 2). In the ewes of group E, a significant (P<0.01) decrease in concentration of IgG from 19.6 mg/mL (before the experiment) to 13.0 mg/mL (1-30 d after parturition) and 9.8 mg/mL (60 d after parturition) was observed. The difference in the average concentration of IgG between group C and E during the entire experiment was not significant, and a similar situation occurred in WBC count. The level of γ-globulins after parturition was significantly lower in group E than in group C.

<table>
<thead>
<tr>
<th><strong>Table 1</strong></th>
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<tr>
<td>The average composition of daily feed ration per ewe with different intake of iodine</td>
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<tr>
<td><strong>Group</strong></td>
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<td></td>
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<tr>
<td>Composition of feed ration</td>
</tr>
<tr>
<td>DM*</td>
</tr>
<tr>
<td>Bulky feed and grains</td>
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<tr>
<td>Mineral mixture</td>
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<tr>
<td>Total iodine content</td>
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<tr>
<td>Iodine content (mg/kg DM)*</td>
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**Table 2**

Selected parameters of immunity in ewes (mean ± SD)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Before experiment</th>
<th>During experiment</th>
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<tbody>
<tr>
<td></td>
<td>without I supplementation</td>
<td>1-30 d after parturition</td>
</tr>
<tr>
<td>IgG*</td>
<td>n1</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>18.2 ±4.0a</td>
</tr>
<tr>
<td>γ-globulins**</td>
<td>12</td>
<td>17.2 ±3.3</td>
</tr>
<tr>
<td>WBC count***</td>
<td>12</td>
<td>5.3 ±0.6c</td>
</tr>
</tbody>
</table>

a; b; c; d; f; g; k; l; m P<0.01; 1 the average of two samplings; 2 the average of three samplings; P<0.05; * mg/mL of blood serum; ** % of blood serum; *** G/L of blood
which the intake of iodine was defined, did not differ in group C and in group E and corresponded to the physiological norm (10). After repeated examinations of these parameters for 30 d after parturition, a decrease in IgG concentration (Table 2) was recorded both in the group C and E. There was no significant difference in IgG concentration between group C and E during the entire experiment. In ewes of group E, a significant decrease (P<0.01) in the average concentration of IgG before the experiment to 13.0 and 9.8 mg/mL after parturition was observed during the entire experiment (1-30 d and 60 d after parturition, respectively). A similar decrease in IgG at high I intake in ewes and in their lambs was reported by other authors (5, 6, 14, 19).

Similarly to IgG, γ-globulins also decreased in both groups after parturition period. In group E γ-globulins decreased (P<0.01) from 16.8% before parturition to 12.7% in the period of 1-30 d after parturition (Table 2). The level of γ-globulins after parturition was significantly lower in group E compared with group C. Our results are consistent with the observations of other authors (14).

In our study, the WBC count increased significantly in both groups only for a transient period of 1-30 d after parturition. The WBC count was constantly on the lower limit of the physiological range (5-11 G/L) (20). Taking into account the influence of the WBC count on immunity, it was important to find out that group E had a lower WBC count during the entire experiment than group C.

**Lambs.** The concentration of IgG (Fig. 1) in lambs of group E was lower (P<0.01) on days 1-30 after birth than in lambs of group C. The concentration of IgG was almost equal in both groups on day 60 after birth. The highest concentration of IgG (22.6 mg/mL) was found in lambs of group C on day 3 after birth. The concentration of IgG also increased significantly after colostrum intake (2, 3).

These results are consistent with results of many studies that have recently demonstrated the negative effect of iodine on plasma immunoglobulin concentrations in lambs (13). In experiment conducted by Rose et al. (19) after application of high doses of iodine (5.5-21 mg/kg dietary DM), a significant decrease in IgG in blood plasma within 24 h post partum was observed. Excessive iodine intake by pregnant ewes possibly causes a change in the physiology of their offspring prior to birth, which lowers the circulating concentrations of IgG (6). These findings are important because the successful absorption of colostral IgG from the gut of the newborn lamb is essential to its viability, as lambs are born hypo-immunocompetent (7) and their serum is virtually void of IgG prior to colostrum feeding (17). Each form of Ig protects the newborn against a specific disease or infection and the placenta of ruminants prevents the transplacental passage of IgG (1).

The influence of iodine on γ-globulins in lambs from day 1 to day 60 after birth is illustrated in Fig. 2. The results showing changes in γ-globulins content correspond with the results of IgG concentration. Obviously, the content of γ-globulins in the lambs from dams in the group E was lower (P<0.01) than in lambs
from dams in the group C from day 1 to day 30 after birth. The WBC count (Fig. 3) was lower within 60 d after birth compared to the lambs of group C but it was statistically significant (P<0.01) only on day 1 after birth.

Iodine deficiency was a frequent problem in farm animals in the past, but at the end of the 20th century and at the beginning of the 21st century the sufficient iodine intake and elimination of pathophysiological forms of its deficiency are successfully solved in the framework of the programme of the World Health Organisation International Council for the Control of Iodine Deficiency Disorders (WHO ICCIDD). It was done mainly by increased or excessive supplementation (23) of iodine in farm animals, which resulted in an increase in its content, particularly in milk (22). Consequently, it may have a negative influence on the health of farm animals and their offspring. The changes in immune parameters in ewes and their lambs, that were revealed in the present study (first of all a significant decrease in IgG and γ-globulin concentrations in the newborn lambs of experimental group), indicate the connection between the long-term excessive iodine intake and a significant reduction in immunity in the early postpartal period in mothers and mainly in the newborns, which is in accordance with recent findings of other research groups (5, 6, 19).

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References

12. EU Commission: Commission Regulation /EC/ No. 1459/2005 of 8 September amending the conditions for authorization of a number of feed additives belonging to the group of trace elements. OJ L 233, 8-10.