YIELD AND COMPOSITION OF MILK AND BLOOD BIOCHEMICAL COMPONENTS OF EWES NURSING A SINGLE LAMB OR TWINS

PRZEMYSŁAW SOBIECH, STANISŁAW MILEWSKI², AND SŁAWOMIR ZDUN CZYK¹

Department of Clinical Sciences, Internal Disease Unit,¹ Reproduction Unit, Faculty of Veterinary Medicine, University of Warmia and Mazury in Olsztyn, 10-957 Olsztyn, Poland
psobiech@uwm.edu.pl
zdun@uwm.edu.pl

²Department of Sheep and Goat Breeding, Faculty of Animal Bioengineering, University of Warmia and Mazury in Olsztyn, 10-917 Olsztyn, Poland
stanislaw.milewski@uwm.edu.pl

Received for publication August 04, 2008

Abstract

The aim of the study was to determine the effect of lactation on blood biochemical components and body weight in Kamieniec ewes nursing singles or twins. The examinations were conducted on 4-year-old ewes; 12 suckling single lambs and 12 suckling twin lambs. The feeding level was maintained constant during a 70-d lactation period. The course and consequences of lactation in ewes nursing singles and twins were compared taking into account daily milk yield, milk production over lactation, milk chemical composition, and blood biochemical indices. Milk yield was found to be significantly (by more than 20%) higher in ewes nursing twins, reaching 27.40% towards the end of lactation. Milk production over lactation was higher in the mothers of twins, by 23.67 kg (P≤0.05). No significant differences were observed between ewes suckling singles and twins with respect to the chemical composition of milk. Changes in blood biochemical indices, primarily in the activity of ALT and AST, concentrations of protein, urea, and creatinine, as well as in the parameters of acid-base balance indicate that lactation has a greater challenge in the ewes nursing twins.

Key words: ewes, lambs, suckling, milk yield, biochemical indices.

Lactation and late pregnancy are critical periods during the reproductive cycle of the ewe. This is confirmed by significant changes in blood biochemical indices, including enzymatic activity and mineral balance, as well as by body weight loss observed during lactation (4). Those negative phenomena are more pronounced in ewes nursing more than one lamb, which is due to the stimulating effect of lambs on milk production. The results of numerous studies indicate that the mothers of twins are characterised by a higher milk yield than the mothers of singles (17, 22). The difference in milk performance between ewes nursing a single lamb or twins is determined by the sheep’s genotype and usually ranges from 10% to 40%, although in Suffolk sheep it may reach even 61% (22). Lactating ewes are usually group-fed, regardless of the number of suckling lambs, and the amount of feed they receive is dependent on their average body weight and fecundity (22). Such a solution, although simple, may lead to nutrient deficiencies in the mothers of twins. This suggests that lactation may have a different influence on the body condition of ewes suckling singles or twins, reflected in the chemical composition of milk (22). This problem, addressed by few authors to date, is of particular importance in meat-type breeds known for their high reproductive potential. An example may be Kamieniec sheep, whose fecundity reaches 150%-170% (26). In the Warmia and Mazury region, the Kamieniec ewes are used as a maternal component for commercial crossing with meat-type rams (5).

The aim of the present study was to determine the effect of lactation on blood biochemical indices and body weight in Kamieniec ewes nursing singles or twins.

Material and Methods

The examinations were performed in the conservation herd of Kamieniec sheep on 24 ewes aged about 4 years, during their third lactation. The animals were divided into two equal groups: 12 suckling single lambs (group 1) and 12 suckling twin lambs (group 2). For the 70-d lactation period, all the ewes were kept together and fed a diet composed of grass and legume...
haylage, meadow hay, and CJ (calves and lambs) concentrate.

The following determinations were made: daily yield and chemical composition of milk on days 14, 28, 42, 56, and 70 of lactation, milk production for the 70-d lactation period, and blood biochemical components on days 2, 28, and 70 of lactation. Daily milk yield was determined based on morning test milking, prior to which the ewes were isolated from the lambs for 12 h. The percentage content of dry matter, fat, protein, and lactose in milk was determined using a CombiFoss 6000 FC apparatus.

Blood samples were taken from the jugular vein. The concentration of glucose was measured by oxidase method; total protein by burette method, urea and creatinine was determined spectrophotometrically using commercial kits, triglycerides by Wako method, and cholesterol by enzymatic method. The activity of aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP) were measured by kinetic method using commercial kits (Alpha Diagnostics). All spectrophotometrical measurements were done using EPOLL 200 spectrophotometer. The level of Na⁺, K⁺, and Cl⁻ was measured by ion-selective method using Easy Lyte Plus apparatus. The parameters of acid-base balance, i.e. pH, partial pressure of carbon dioxide (pCO₂), partial pressure of oxygen (pO₂), bicarbonate concentration (HCO₃⁻), base excess (BE), oxygen saturation of haemoglobin (O₂SAT), and the concentration of carbon dioxide (ctCO₂) were determined with a Corning 248 blood gas analyser.

The results were analysed statistically in a one-factor orthogonal design. The significance of differences between mean values in groups was verified by the Duncan’s test with respect to biochemical indices, and by the Student’s t-test with respect to the remaining parameters.

Results

The data of milk characteristics are presented in Fig. 1 and in Table 1.

The daily milk yield was statistically higher in ewes nursing twins at all stages of lactation at P ≤ 0.05 on days 14, 28, and 42, and at P ≤ 0.01 on days 56 and 70 (Fig. 1). Milk production (Table 1) throughout lactation was 107.15 kg in the group 1 and 130.82 kg in the group 2, and the difference was found to be statistically significant (P ≤ 0.01).

![Fig. 1. Daily milk yield](image_url)

a, b - P ≤ 0.05
A, B - P ≤ 0.01
### Table 1
Production and composition of milk

<table>
<thead>
<tr>
<th>Specification</th>
<th>Group 1</th>
<th></th>
<th>Group 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk production per lactation (kg)</td>
<td>107.15$^\text{a}$</td>
<td>12.89</td>
<td>130.82$^\text{A}$</td>
<td>21.66</td>
</tr>
<tr>
<td>Composition of milk (%):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fat</td>
<td>5.52</td>
<td>0.83</td>
<td>5.71</td>
<td>0.25</td>
</tr>
<tr>
<td>protein</td>
<td>4.72</td>
<td>0.37</td>
<td>4.56</td>
<td>0.41</td>
</tr>
<tr>
<td>lactose</td>
<td>5.31</td>
<td>0.21</td>
<td>5.42</td>
<td>0.11</td>
</tr>
<tr>
<td>dry matter</td>
<td>16.07</td>
<td>1.00</td>
<td>16.16</td>
<td>0.72</td>
</tr>
</tbody>
</table>

### Table 2
Biochemical components of blood of ewes

<table>
<thead>
<tr>
<th>Components</th>
<th>Group 1</th>
<th></th>
<th>Group 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day of lactation</td>
<td>Day of lactation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.</td>
<td>28.</td>
<td>70.</td>
<td>2.</td>
</tr>
<tr>
<td>Glucose (mmol/L)</td>
<td>3.36</td>
<td>0.64</td>
<td>3.52</td>
<td>0.40</td>
</tr>
<tr>
<td>Total protein (g/L)</td>
<td>70.22</td>
<td>3.12</td>
<td>71.56</td>
<td>3.66</td>
</tr>
<tr>
<td>ALT (IU/L)</td>
<td>10.86$^\text{b}$</td>
<td>6.26</td>
<td>15.32$^\text{a}$</td>
<td>6.13</td>
</tr>
<tr>
<td>AST (IU/L)</td>
<td>62.21$^\text{b}$</td>
<td>8.99</td>
<td>85.11$^\text{a}$</td>
<td>9.14</td>
</tr>
<tr>
<td>ALP (IU/L)</td>
<td>133.65</td>
<td>49.15</td>
<td>147.93</td>
<td>43.62</td>
</tr>
<tr>
<td>Cholesterol (mmol/L)</td>
<td>2.05</td>
<td>0.51</td>
<td>1.96</td>
<td>0.52</td>
</tr>
<tr>
<td>Triglycerides (mmol/L)</td>
<td>0.19</td>
<td>0.06</td>
<td>0.23</td>
<td>0.05</td>
</tr>
<tr>
<td>Urea (mmol/L)</td>
<td>4.24$^\text{b}$</td>
<td>0.59</td>
<td>5.05$^\text{b}$</td>
<td>0.84</td>
</tr>
<tr>
<td>Creatinine (µmol/L)</td>
<td>117.25</td>
<td>12.39</td>
<td>119.75</td>
<td>10.53</td>
</tr>
<tr>
<td>Na$^+$ (mmol/L)</td>
<td>144.00</td>
<td>3.79</td>
<td>142.77</td>
<td>4.96</td>
</tr>
<tr>
<td>K$^+$ (mmol/L)</td>
<td>5.03</td>
<td>1.25</td>
<td>4.93</td>
<td>0.45</td>
</tr>
<tr>
<td>Cl$^-$ (mmol/L)</td>
<td>110.70</td>
<td>2.27</td>
<td>109.23</td>
<td>2.79</td>
</tr>
<tr>
<td>pH</td>
<td>7.40</td>
<td>0.03</td>
<td>7.40</td>
<td>0.04</td>
</tr>
<tr>
<td>pCO$_2$ (kPa)</td>
<td>5.21$^\text{b}$</td>
<td>0.50</td>
<td>5.35</td>
<td>0.79</td>
</tr>
<tr>
<td>pO$_2$ (kPa)</td>
<td>6.56</td>
<td>1.11</td>
<td>6.24</td>
<td>0.91</td>
</tr>
<tr>
<td>HCO$_3^-$ (mmol/L)</td>
<td>25.31$^\text{a}$</td>
<td>1.51</td>
<td>23.73</td>
<td>1.42</td>
</tr>
<tr>
<td>BE (mmol/L)</td>
<td>0.41</td>
<td>1.63</td>
<td>-0.61</td>
<td>1.53</td>
</tr>
<tr>
<td>O$_2$ SAT (%)</td>
<td>80.85$^\text{a}$</td>
<td>8.83</td>
<td>77.64</td>
<td>7.22</td>
</tr>
<tr>
<td>ctCO$_2$ (mmol/L)</td>
<td>24.67</td>
<td>1.50</td>
<td>25.01</td>
<td>2.10</td>
</tr>
</tbody>
</table>

$^a$ $b$ - P$\leq$0.05, A B - P$\leq$0.01
Blood biochemical components are shown in Table 2. Serum glucose concentrations were comparable in all ewes and the observed variations remained within the normal range. Total protein increased insignificantly in the group 1, while in the group 2 it decreased significantly on day 28 (P<0.05) and remained at this level until the end of lactation. Protein content was lower in the mothers of twins than in the mothers of singles.

Cholesterol level was similar in ewes of both groups, and it dropped inconsiderably during lactation. Triglyceride content was also comparable in all ewes, and it rose slightly with the progress of lactation. Urea concentration increased significantly (P≤0.05) in ewes of both groups over lactation, and the average level of this parameter was higher in the mothers of twins. Creatinine content rose in all ewes during lactation, but this increase was statistically significant (P≤0.05) only in the group 2. Average creatinine level was higher in ewes nursing twins. Throughout lactation, significant (P≤0.05) changes were observed in both groups of ewes with regard to ALT and AST activity. In ewes suckling singles, the highest activity of these enzymes was with regard to ALT and AST activity. In ewes suckling twins, enhanced activity of these enzymes was reported on days 28 and 70. The activity of ALP increased during lactation in both groups.

The levels of Na⁺, K⁺, and Cl⁻ fluctuated slightly but the observed differences were non-significant and fell within the normal range. As regards the parameters of acid-base balance, an inconsiderable drop in pH during lactation was accompanied by a rise in pCO₂ (significant in both groups), ctcO₂ (significant in group 2), a drop in HCO₃⁻ (significant in both groups), a slight decrease in PO₂ and a decrease in O₂SAT (significant in both groups). BE values showed no statistically significant differences, reaching the lowest level on day 28 in ewes nursing single lambs and at the beginning of lactation in ewes suckling twin lambs.

Discussion

Ewes suckling twins were characterised by a higher milk yield and higher (by 22.09%) milk production during 70-d lactation than ewes nursing singles, which is consistent with the findings of other authors (17, 22).

The difference between the groups was more pronounced in the second half of lactation. This corresponds to the opinion of Snowder and Glimp (22), who claim that milk production in the mothers of twins is stimulated to a higher degree in later phases of lactation. In the current study, the proximate chemical composition of milk was not affected by litter size. However, the results reported by other authors show certain differences in this respect. Snowder and Glimp (22) and Sormunen-Cristian et al. (24) demonstrated that the milk of ewes nursing twins contained more fat, while Niżníkowski et al. (18) noted only a higher lactose concentration in the milk of the mothers of twins. On the other hand, a lower lactose content in the milk of ewes suckling twin lambs was reported by Snowder and Glimp (22). Niżníkowski et al. (18) studied milk composition in Corriedale and Friesian sheep and observed significant differences only with respect to Corriedale ewes. This was indicative of the genotype effect.

Higher milk production in ewes nursing twins resulted from their enhanced metabolic activity, reflected in variations in blood biochemical indices during lactation. Glucose levels fluctuated slightly in ewes of both groups, and at the second stage of lactation serum glucose concentration was somewhat lower in the mothers of twins. Authors vary in their opinions regarding changes in this parameter in lactating ewes. According to El-Sheriff and Assad (9), serum glucose concentration is considerably lower in lamb ewes than in maiden ewes, or older ewes, whereas Firat and Ozpinar (10) observed no alterations in glucose levels during gestation and lactation. In ruminants, tissue responsiveness to insulin is reduced during lactation, which may induce a temporary increase in serum glucose concentration, thus stimulating milk yield (27). Most authors (11) agree that glucose concentration in ewes increases in the initial phase of lactation and decreases before the drying-off period. A similar pattern of changes in glucose levels was noted in the mothers of twins in the present study.

Total protein content varied slightly in the group 1 and dropped significantly in ewes nursing twins, reaching the lowest level at the peak of lactation. Similar trends were described by El-Sheriff and Assad (9). The observed decline in total serum protein, correlated with a rise in milk yield, is caused by the intensive synthesis of milk proteins. According to some authors (23), it is accompanied by a decrease in the serum concentrations of albumins and globulins. On the other hand, Antunovic et al. (1) pointed to an increase in total protein levels with the progress of lactation, accompanied by a drop in the serum concentrations of globulins (in particular α₁– and γ-globulin fractions). A similar growing trend was noted in the group 1 in the current experiment.

Serum triglyceride levels were comparable in all ewes and increased insignificantly during lactation. This rise was a consequence of the negative energy balance accompanied by fat mobilisation in adipose tissue, observed over lactation. The authors, who analysed fat metabolism in ruminants (20), pointed to the fact that in cases of severe energy deficiency, triglycerides formed from reserve fat are transported directly to the liver, thus increasing the risk of fatty liver disease developing usually in early lactation. In the present study, triglyceride levels fluctuated slightly and remained within the normal physiological range. Cholesterol concentrations, in contrast to triglyceride content, decreased insignificantly in all animals during lactation. A decline in this parameter was also observed by other authors (13), who reported the highest cholesterol levels in ewes during gestation and...
immediately postpartum. This phenomenon is due to the oestrogen stimulation of cholesterol synthesis (15). The results of the present study suggest that the intensity and course of lactation have no effect on serum cholesterol levels in ewes.

Urea levels increased significantly throughout lactation in ewes of both groups and urea content was higher in the mothers of twins. Similar results were obtained by Brzostowski et al. (4). Changes in serum urea levels observed in the current study confirm the hypothesis proposed by El-Sheriff and Assad (9) that this parameter in lactating ewes is closely correlated with milk production and protein concentration in milk. In the group 2, there was a negative correlation between total protein levels and the content of urea - one of the end products of protein metabolism. This is associated with protein catabolism during intensive milk synthesis, described by Doornenbal et al. (8). Similarly to urea levels, also serum creatinine concentrations increased in all ewes during lactation, and the recorded changes were significant in the group 2. However, these results contradict the findings of Rodriguez et al. (23) who reported that lactation had no effect on the creatinine index. The significant rise in serum creatinine over lactation is related to the elevated urea levels and intensive protein turnover in lactating ewes.

The activity of ALT and AST increased during lactation in ewes of both groups. The highest AST activity was recorded in all ewes at the peak of lactation. ALT activity reached the highest value at the peak of lactation in the group 1 and towards the end of lactation in the group 2. Enhanced activity of both liver enzymes indicates the stimulation of hepatic functions associated with higher productivity. Karadjole et al. (16) noted the highest activity of AST and ALT in the second month of lactation, followed by a gradual decrease at the end of lactation. Other authors (10) emphasise a positive correlation between AST activity, milk yield, and the activity of the mammary gland in small ruminants. This is in line with the results of the present study, in which AST activity increased significantly in the mothers of twins on day 28 of lactation, when milk production was the highest. The activity of ALP increased insignificantly in all animals with the progress of lactation. Similar trends were observed by Sato et al. (27) in cows and by Masek et al. (18) in sheep. These authors demonstrated that serum ALP levels were substantially higher over lactation than during the drying-off period. This could be due to the enhanced activity of ALP isoenzymes produced primarily in the liver and in the bones. It is also suggested that ALP originating from the mammary gland may affect the serum activity of this enzyme.

In both groups of animals, the lowest sodium content was noted on day 28 of lactation (i.e. at peak milk yield), but the content was somewhat lower in ewes nursing twins than in those nursing singles. The above results testify to a negative correlation between the amount of milk produced and sodium level. Baranowski (4) pointed to serum sodium deficiency in ewes during the first two months of lactation, resulting from the transfer of this nutrient into milk. On the other hand, Azab et al. (3) claim that in ruminants this electrolyte drops to the lowest level immediately postpartum, which is related to the flow of sodium ions to colostrum. It should be noted, however, that the fluctuations in serum sodium levels reported in this study were small and had no influence on the health status of ewes. Potassium ion concentrations, unlike sodium ion content, dropped in both groups of the animals during lactation. According to Hu and Murphy (14), the serum levels of both electrolytes in ruminants are independent of the concentrations of sodium and potassium in the diet. The serum levels of Na⁺ and K⁺ are determined primarily by their excretion through the kidneys. In high-producing animals, an important role is also played by the transfer of the electrolytes into milk. Maintaining a constant level of potassium ions is a prerequisite for homeostasis, since substantial fluctuations in the content of this electrolyte may lead to structural and functional disorders of, among others, the cardiac muscle, smooth muscles, and skeletal muscles (32). A decline in the serum levels of K⁺ observed in ewes was insignificant, and potassium content fell within the reference range. The serum levels of chloride ions were similar in all ewes and did not change over lactation. Hu and Murphy (14) suggest that the serum concentrations of chlorides are affected mostly by the supply of these ions in the diet. The levels of chloride ions are also closely correlated with the parameters of acid-base balance. The small fluctuations in these parameters, observed in the present study, were not related to Cl⁻ concentrations, which remained stable throughout lactation.

The analysis of the parameters of acid-base balance revealed a slight drop in pH, a rise in the partial and total pressure of carbon dioxide, a drop in the partial and total pressure of oxygen, in bicarbonate concentration, and in the oxygen saturation of haemoglobin. The above changes concerned both the metabolic component (a decrease in bicarbonate concentration and in the oxygen saturation of haemoglobin) and the respiratory component (an increase in the partial and total pressure of carbon dioxide). It should be stressed that the observed mild disturbances in the acid-base balance were more noticeable in the mothers of twins, characterised by substantially higher milk productivity. The mechanisms involved may include fat mobilisation (the acquisition of greater amounts of energy) and – in consequence – the production of greater quantities of organic acids, affecting the parameters of the balance. The formation of larger amounts of acid radicals during lactopoesis is associated with enhanced metabolic activity and the buffering of radicals by bicarbonate ions, which reduces their blood concentrations (7). Similar phenomena were described by Piccione et al. (22) and Castillo-Rodriguez et al. (8) who investigated changes in the acid-base balance in lactating ewes.

Milk production and the energy expenditure associated with this process have a profound impact on the metabolism, manifested by slight alterations in homeostasis followed by acid-base balance disorders.

In summarising, it was demonstrated that milk production during lactation was higher in the mothers of
twins. No significant differences were observed between ewes suckling singles and twins with respect to the chemical composition of milk. Changes in blood biochemical indices, primarily in the activity of ALT and AST, the concentrations of protein, urea, and creatinine, as well as in the parameters of acid-base balance indicate that lactation has a greater challenge in ewes nursing twins.

References