CHANGES IN COW ACTIVITY, MILK YIELD, AND MILK CONDUCTIVITY BEFORE CLINICAL DIAGNOSIS OF KETOSIS, AND ACIDOSIS

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Abstract. The objective of the research: to assess changes in milk yield, animal activity, and milk conductivity before clinical diagnosis of ketosis, and acidosis. For the purpose of the present research, in total 90 fresh dairy cows were selected (up to 60 days-in-milk). They were grouped according to the disease as follows: cows with ketosis (n = 30), acidosis (n = 30), and control group, i.e., healthy cows (n = 30). The parameters recorded by the herd management software were analyzed for 12 days before clinical diagnosis of the disease and during its course.

In cows sick with ketosis the milk yield showed a tendency of most significant decrease 8 days before clinical symptoms. On the day of disease detection, the activity was found to increase by 21.5 %, when compared to the day 12 before emergence of clinical symptoms of the disease ($p<0.0001$), however this increase was most pronounced 2 days before the detection of the disease (3.1–3.7 %; $p<0.001$). The major increase in milk conductivity was observed 2 days before the emergence of clinical symptoms (3.1–3.7 %; $p<0.001$).

In cows sick whit acidosis the milk yield tended to decrease most significantly 6 days ($p<0.01$) before the emergence of clinical symptoms. The variation of animal activity in the period under research was diverse. Its significant increase was observed 2 days before the emergence of clinical symptoms of the disease ($y = 2.9x + 20.667$; R2 = 0.839). Starting with days 6–7 before the detection of disorders under consideration, a gradual increase in milk conductivity was observed. Indicators recorded by the herd management software and assessed during the period of investigation are considered to serve as the diagnostic algorithm for ketosis and acidosis.

Keywords: acidosis, ketosis, milk yield, activity, conductivity

Introduction. One of the most critical periods in respect of physiology of cows is a postpartum period. For cows, this period lasts until the next insemination i.e., for 2–3 months. The sum of postpartum-specific disorders normally occurs in the first 10 days after calving (Ingvartsen et al. 2003). Before and after the parturition cow's body is subject to various changes of endocrine system, metabolism, and digestive system. These changes have further effect of dry matter intake (DMI), and impair the energy balance from feed intake. In the background of negative energy balance, some metabolic disorders tend to develop such as fatty liver disease and ketosis (Spain, Scheer, 2001). According to Hammon et al. (2006), cows suffering from reproductive disorders (metritis and endometritis) show increased plasma non-esterified fatty acid (NEFA) concentrations. Elevated concentration of these acids is considered to be a symptom indicative of ketosis. Duffield et al (2009) reported the cumulative incidence of subclinical ketosis over the first 9 weeks of lactation in 507 untreated cows from 25 Holstein dairy farms in Ontario, Canada was 59 % and 43 % using cut-off threshold beta-hydroxybutyrate (BHBA) concentrations of 1200 and 1400 μmol/L (11.5 and 13.6 mg/dL). Correa et al., (1993) found that ketosis increased the risk of abomasal displacement, but not the reverse. Dohoo and Martin (1984) could find no direct association between the two conditions. The onset of lactation and feed change often result in disorder of digestive system known as acidosis. Sub-acute ruminal acidosis (SARA), defined as periods of moderately depressed ruminal pH, is one of the most common chronic digestive disorders, especially in well-managed dairy herds. High-producing dairy cows are at greater risk of SARA because their diets often contain a high concentrate-to-forage ratio or a high percentage of easily fermentable carbohydrates to meet the high demand for energy (Stone 2004). SARA can result in decreased DMI, milk production, and milk fat content, and cause diarrhoea and lameness, as well as an increase in mortality (Plaizier et al. 2008). All the postpartum disorders have a negative effect on milk yield, reproduction, and cow immunity (Spain, Scheer, 2001). In cows, which in latest stages of lactation have endometritis and whose somatic cell count (SCC) has increased (over 300000 cels/ml) 25 days pp (post partum), milk conductivity and walking activity are increscent (Antanaitis et al., 2010). It is extremely important to detect postpartum disorders as early as possible while using only trustworthy techniques. Timely assessment of cow condition prevents complications that occur in postpartum period. It is absolutely necessary to detect diseases effectively as the majority of postpartum complications occur in subclinical form in the beginning (Oetzel, 2003). For this purpose, a comprehensive evaluation of changes in parameters such as cow activity, body weight, milk production, milk conductivity, and milk composition recorded by herd management software is highly valuable. It facilitates early detection of disorders and adaptation of preventive measures as well as prevention of progressive complications of postpartum period (Sederevicius et al., 2007).

The objective of the present research was to assess the changes in milk production, animal activity, and milk conductivity before clinical diagnosis of ketosis and acidosis.

Materials and methods. The research was performed in the period from January 2011 to October 2012 at agricultural company “X” with the total cattle number of 2018 including 856 dairy cows of Lithuanian Black and White breed, with the average milk production of 7500 kg per lactation. In this farm, cows were housed in a loose-housing “cold” barn. Cows were fed according to rations individually made for each group of cows based on their physiological needs. Cows were milked twice a day in a rotary parlour. No seasonality of calving was present. Herd management and accounting was performed using herd management software “DairyPlan C21” (Germany) to record the following main physiological data: milk production (in kg), animal activity (number of steps per hour), and milk conductivity (in mS/cm). Each cow data was recorded at every milking session and stored in the computer memory.

For the purpose of the research, the total of 90 fresh dairy cows was selected (up to 60 days-in-milk). They were grouped according to the disease as follows: cows with ketosis (n = 30), cows with acidosis (n = 30), and control group, i.e., healthy cows (n = 30).

The disorders were diagnosed based on clinical symptoms as follows: ketosis – based on the decreased appetite, increased plasma ketone body concentration, and decreased milk production. The cow was considered to have a ketosis problem if no systematic disorders were detected, feed intake was decreased by 50 %, rumen was not filled, plasma ketone body concentration was above 1200 µmol/l, and milk production was lower by at least 20 % when compared to the average milk yield of the previous day. Plasma ketone body level was found using *Medisense* system of *Free styleOptiumH* (Great Britain) from the sample of capillary blood of the ear. Acidosis was identified indirectly, based on the consistency of the faeces and contained undigested feed particles, and weakened peristaltic motion through the rumen. The cow was considered to have acidosis when diarrhoea was observed, rumen motoric activity was below 2 times per 2 minutes, and undigested feed particles were visually observed in faeces (Tajik, Nazifi, 2011). Three parameters were selected to be measured, namely milk production, milk conductivity, and cow activity, and their changes were recorded for 12 days before clinical diagnosis of the disease.

The parameters recorded by the herd management software were analyzed for 12 days before clinical diagnosis of the disease and during its course.

The research data was processed using SPSS statistical package (SPSS for Windows 15.0, SPSS Inc.,Chicago, IL, USA, 2006). The data was considered statistically reliable when $p<0.05$.

Discussion. The milk production of all sick cows was found to be by 7.1 % lower on the average ($p<0.0001$) when compared to that of the group of healthy cows. On days 9–12 before diagnosis of a disease, milk losses amounted to 1.1 %, on days 4–8 to 3.2 %, and on days 1–7 to 13.1 %, whereas on the day of diagnosing the disease milk production of sick cows was found to be by 22.2 % lower than that of healthy cows. Selection of cows based on their milk yield increases probability of their higher morbidity (Van Dorp et al., 1998). Lactation and milk production of a cow are influenced by health traits of a cow. In the period under investigation, the maximum difference in milk yield, when compared to a group of healthy cows, was found in cows diagnosed with ketosis (7.1 %; $p<0.01$). The anti-ketogenic therapy was found to have a positive effect on milk production (McArt et al., 2011). In other words, ketosis has a negative effect on cow‘s productivity. According to the available data, each case of ketosis results in milk losses of up to 10 kg per day (Antanaitis et al., 2010). Ketosis has an effect on decreasing milk production for 2–4 weeks prior to its clinical diagnosing (Rajala et al., 1999). In general, there is a consensus that a negative association between hyperketonemia and milk production exists; however, there are conflicting reports and the associations are complex. In one study, the loss of production associated with a positive milk ketone test was 1.0 to 1.4 kg of milk per day (Dohoo and Martin, 1984). This represented 4.4% to 6.0% of the mean test day milk production. Forecasting using linear regression (Table 1) showed that milk yield of cows sick with ketosis tended to decrease most significantly for the last 8 days ($y = -0.5029x + 33.827$; $R2 = 0.8934$) of their clinical symptoms (Fig. 1).

Cattle activity is associated with symptoms used to define health condition, and it normally increases before emergence of clinical symptoms of some disorder (Edwards, Tozer 2004). In accordance with J. B. Adewuyiand other researchers (2006), activity of an animal and variation in milk production are considered to reliably indicate pathological changes taking place in the body. A negative correlation was found to exist between the activity and the following symptom of ketosis – increased plasma non-esterified fatty acid (NEFA) concentration. The increase in animal activity before detection of a disease might be associated with the increasing stress (Antanaitis et al., 2010).

As the graph in Fig. 2 shows, in the period under investigation, the activity of cows diagnosed with ketosis was by 9.8 % higher, on the average, when compared to the group of healthy cows ($p<0.001$). On the day of disease detection, the activity of cows sick with ketosis was found to increase by 21.5 %, when compared to the day 12 before emergence of clinical symptoms of the disease ($p<0.0001$). (Fig. 2). Based on the regression analysis, the activity of cows sick with ketosis (Table 2) tends to increase for the entire period under research ($y = 1.2353x + 75.571$;$R2= 0.7403$), however this increase is the most pronounced 2 days before the detection of the disease. Edwards and Tozer (2004) found that ketotic cows had lower activity than healthy cows up to day 5, and then became more active after 12 days.

Špakauskas V. and scientific group (2006) found milk conductivity (EC) of cows under investigation to vary in range from 4.3 to 5.7 mS/cm. In case of udder inflammation, electric conductivity increases from 6.1 to 8.5 mS/cm.

Norberg E. et al. (2004) found the average conductivity of cows investigated in Denmark to amount to 4.87 mS/cm.

As Fig. 3 shows, milk conductivity of sick cows with ketosis was higher than that of healthy cows: by 1.6 % ($p<0.001$). In the group of cows sick with ketosis, the major increase in milk conductivity was observed 2 days before the emergence of clinical symptoms of the disease (3.1 – 3.7 %; $p<0.001$). The tendency of linear increase in milk conductivity for 12 days before the emergence of clinical symptoms of ketosis ($y = 0.0341x + 9.7814$; $R^2 = 0.8916$). Electrical conductivity of milk is a reverse measure of milk resistance, dependent on the intensity of response by blood vessels. It is dependent on sodium Na+, potassium K+, calcium Ca+, magnesium Mg+, chlorine Cl- and other ions content in milk, i.e., the changes in concentration of ions determine the increase in milk conductivity (Hamann, Gyodi, 2000). Naturally, pathogenic process starts on a cellular level, and further proceeds while affecting many systems (Yong qing Guo et al., 2013). These changes are reflected in concentration of ions and conductivity of biological fluids. The particular early change in milk conductivity before the clinical form of a disorder evidences a long-term effect of the etiological factor of the disease.

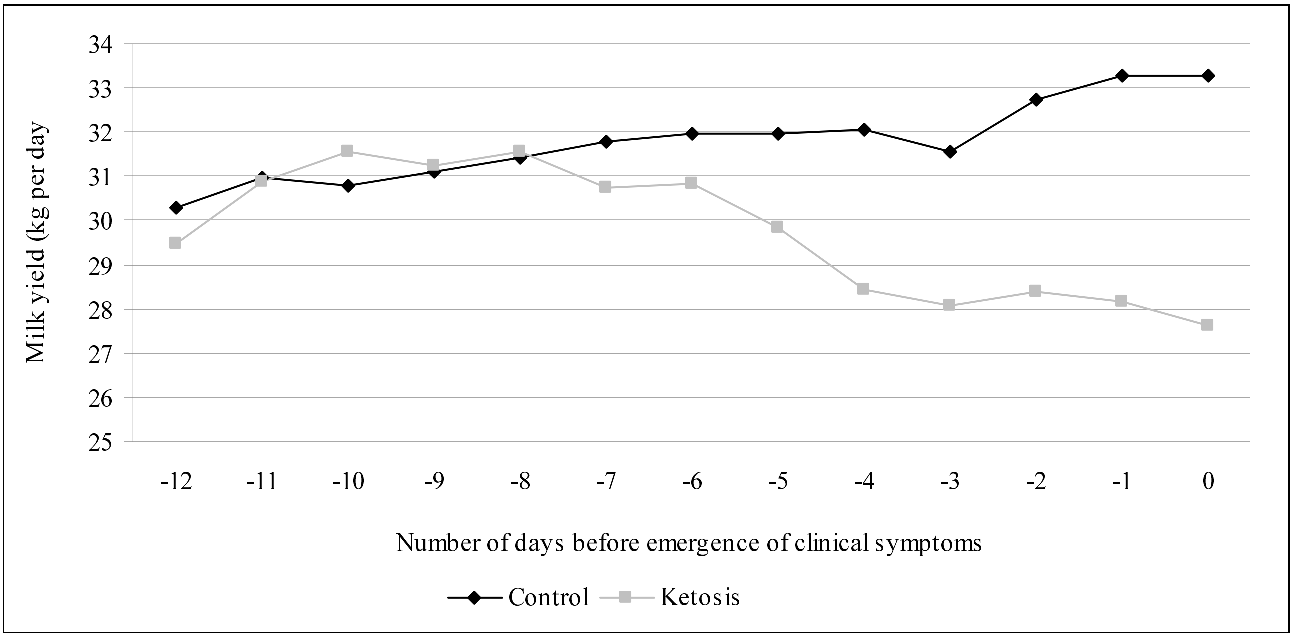

Fig. 1. **Milk yield of the sick ketosis and control cows**

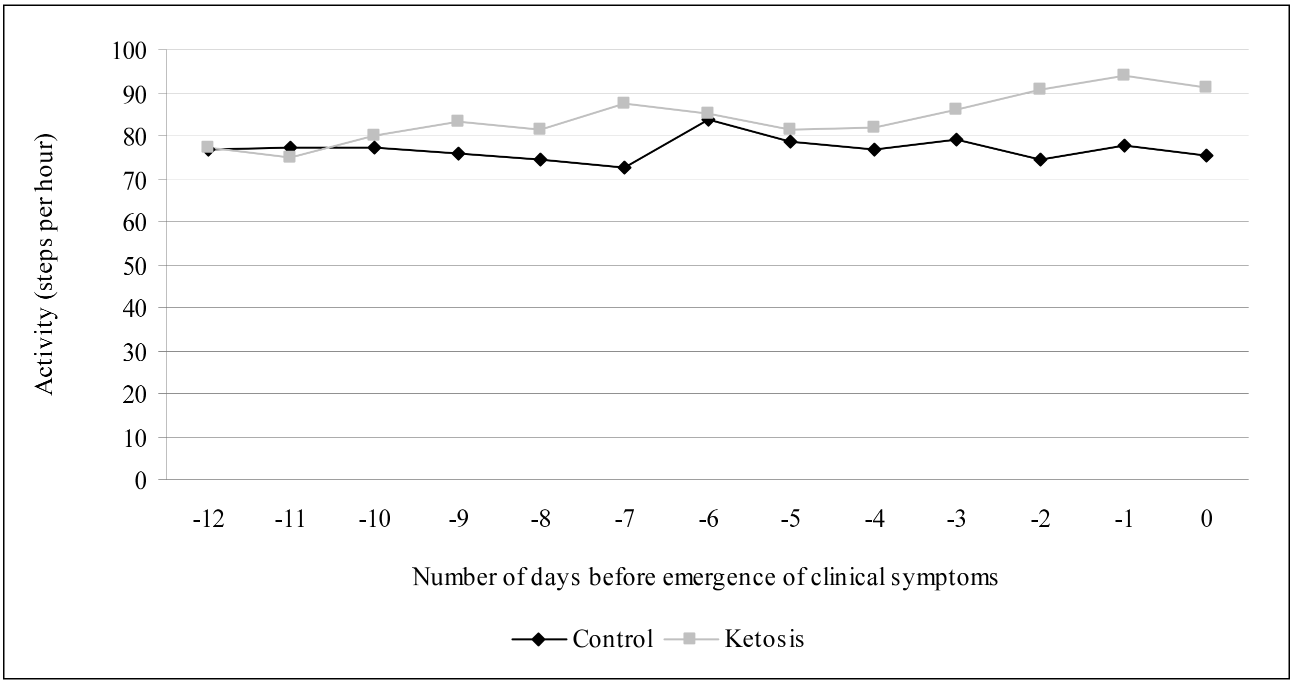

Fig. 2. **Activity of the cows with ketosis and control cows**

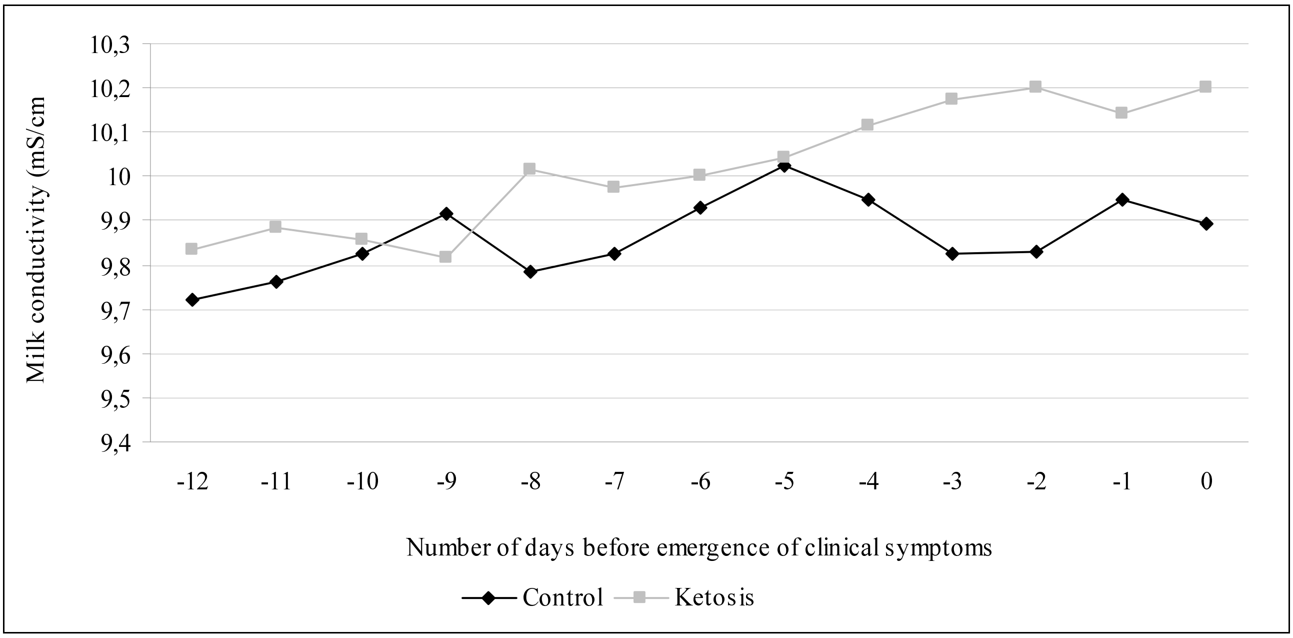

Fig. 3. **Milk conductivity of cows with ketosis and control cows**

In the period under investigation, the minimum difference was found in cows with acidosis (5.1 %; p<0.01). The significant decrease of milk production was observed on days 3–4 before the occurrence of clinical symptoms of the diseases under investigation, whereas on the day of disease emergence total milk losses due to acidosis amounted before 6 days (p<0.01). Forecasting using linear regression (Table 1) showed that milk yield of cows sick with acidosis tended to decrease most significantly ($y = -0.9525x + 40.426$; $R2 = 0.8715$) 2 days before emergence of their clinical symptoms. In case of acidosis, milk production is directly dependent on the function of digestive system. Clinical case of acidosis works in well with minimum feed intake and significant decrease in milk production (Fig. 4).

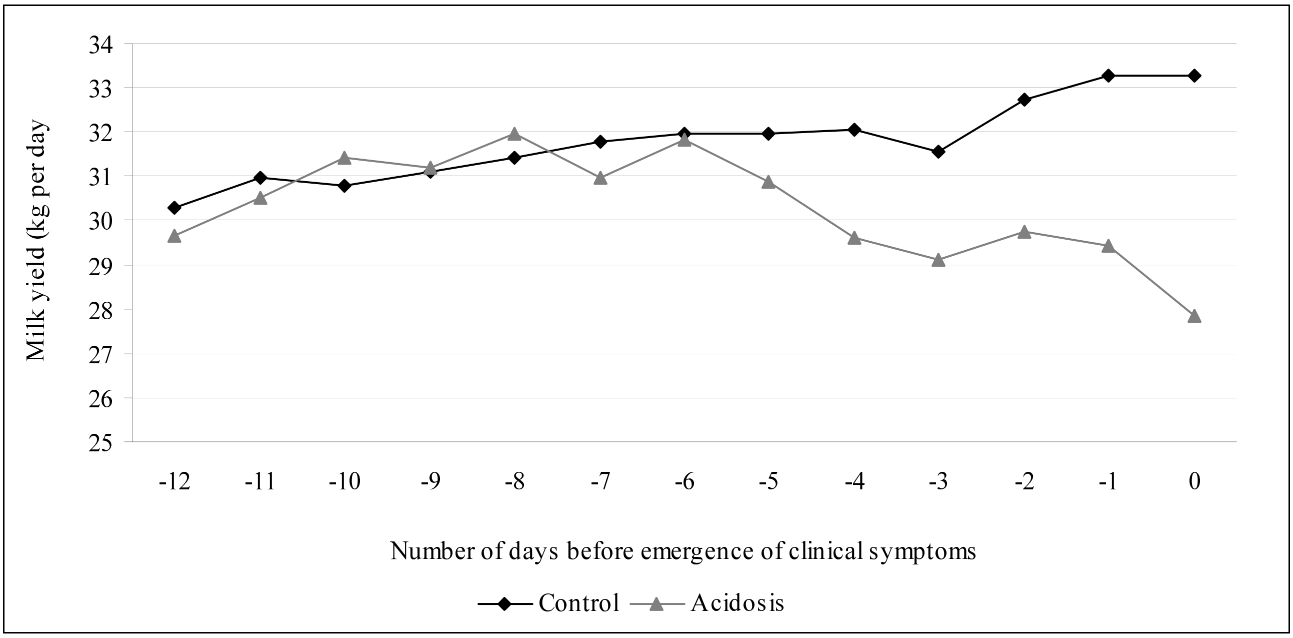

Fig. 4. **Milk yield of cows with acidosis and control cows**

As the graph in Fig. 5 shows, in the period under investigation, the activity of cows diagnosed with acidosis was by 18.7 % lower on the average when compared to the group of healthy cows (p<0.001). On the day of disease detection, the activity of cows sick with acidosis was found to decrease by 27.5 and 23.3 %, respectively, when compared to the day 12 before emergence of clinical symptoms of the disease (p<0.0001) (Fig. 5).

In the group of cows sick with acidosis, the variation of animal activity in the period under research was diverse. Its significant increase was observed 2 days before emergence of clinical symptoms of the disease (y = 2.9x + 20.667; R2 = 0.839). Cows clinically diagnosed with general digestive disorders had lower activity than sick cows after 4 days, indicating that when cows have these disorders they are not active.

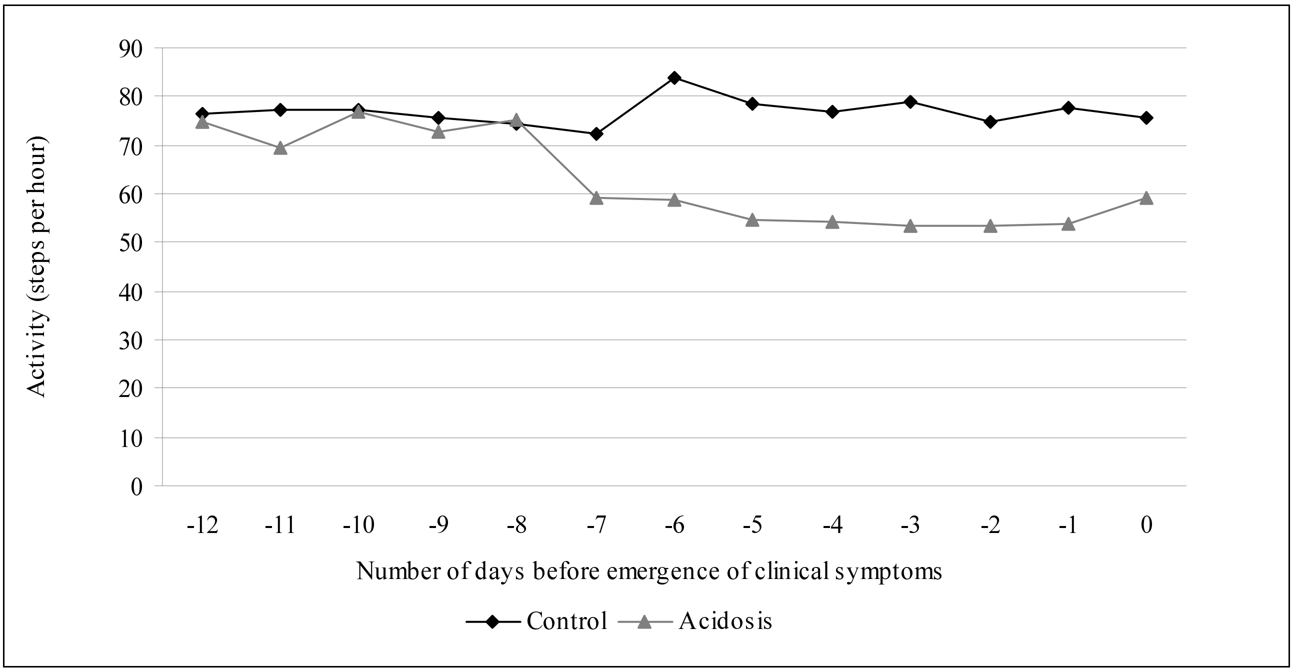

Fig. 5. **Activity of cows with acidosis and control cows**

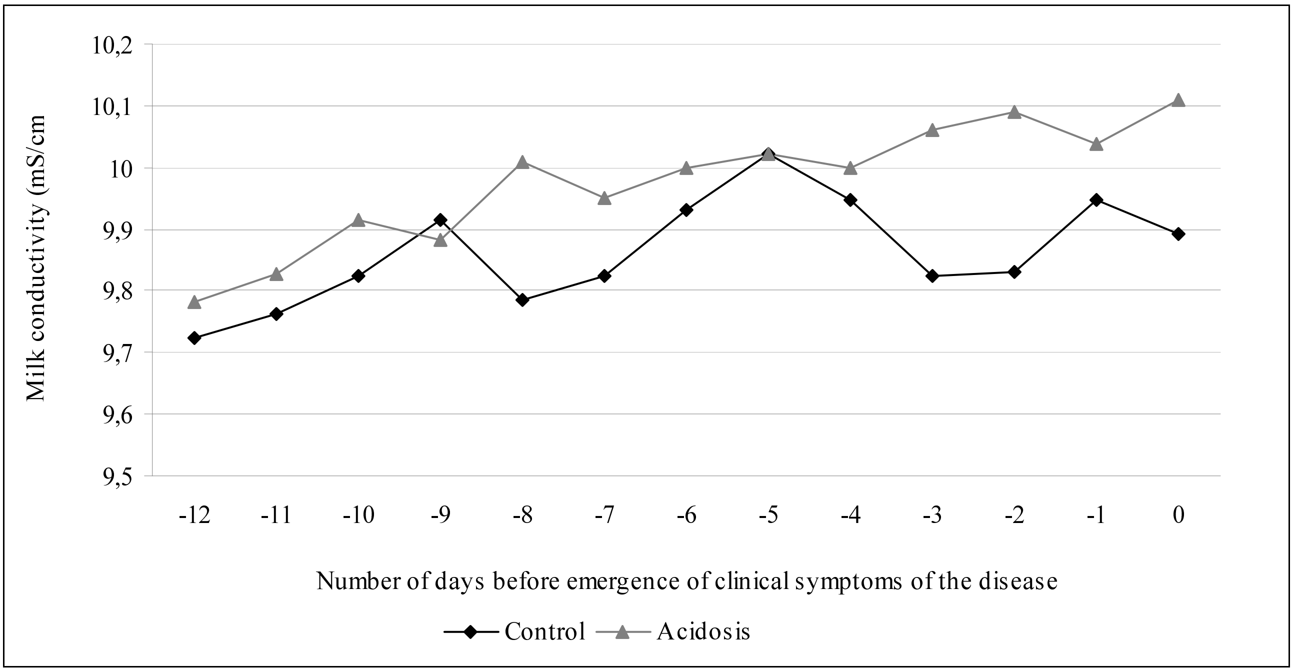

Fig. 6.**Conductivity of the sick acidosis and control cows**

As Fig. 6 shows, milk conductivity of sick cows with acidosis was higher than that of healthy cows: by 1.2 % ($p<0.001$). Starting with days 6–7 before detection of disorders under consideration, a gradual increase in milk conductivity was observed (Fig. 6). In the group of cows sick with acidosis, the major increase in milk conductivity was observed 2 days before the emergence of clinical symptoms of the disease (2.6–3.3 %; $p<0.001$). The tendency of linear increase in milk conductivity for 12 days before the emergence of clinical symptoms of acidosis ($y = 0.0237x + 9.81$; $R^2 = 0.8544$) is evidenced by the results of regression analysis, presented in Table 3.

The particular early change in milk conductivity before the clinical form of a disorder evidences a long-term effect of the etiological factor of the disease. The disease is diagnosed clinically when the deficiency of compensation mechanism occurs (Raphael, Carty, 2013). Acidosis has no significant influence on milk conductivity, which is proved by low coefficient of determination.

Table 1. **Regression analysis of milk yield of cows under research**

Disease	Number of days before emergence of clinical symptoms of the disease					
	12	10	8	6	4	2
Ketosis	y =-0.297x + 31.839; R2 = 0.6272	y =-0.4468x + 33.255; R2 = 0.9078	y = -0.5029x + 33.827; R2 = 0.8934	y = -0.4687x + 33.46; R2 = 0.783	y = -0.1615x + 29.92; R2 = 0.5946	y = -0.3892x + 32.726; R2 = 0.9548
Acidosis	y =-0.1884x + 31.642; R2 = 0.3713	y =-0.3415x + 33.096; R2 = 0.7589	y = -0.4506x + 34.209; R2 = 0.8294	y = -0.5307x + 35.09; R2 = 0.7995	y= -0.3279x + 32.755; R2 = 0.4543	y = -0.9525x + 40.426; R2 = 0.8715

Table 2. **Regression analysis of variation in activity of cows under research**

Disease/ Day	12	10	8	6	4	2
Ketosis	y = 1.2353x + 75.571; R2= 0.7403	y = 1.0992x + 76.895; R2 = 0.6124	y = 1.2667x + 75.165; R2 = 0.5529	y = 1.8899x + 68.304; R2 = 0.6979	y = 2.65x + 59.667; R2 = 0.7719	y = 0.3333x + 87.972; R2 = 0.0322
Acidosis	y = =-2.0203x + 76.842; R2 = 0.6954	y = -2.2255x + 78.822; R2 = 0.6394	y = -1.53x + 71.737; R2 = 0.3663	y = -0.0536x + 55.893; R2 = 0.0021	y = 1.03x + 43.47; R2 = 0.4443	y = 2.9x + 20.667; R2 = 0.839

Table 3. **Regression analysis of variation in milk conductivity of cows under research**

Disease/ Day	12	10	8	6	4	2
Ketosis	y = 0.0341x + 9.7814; R2 = 0.8916	y = 0.037x + 9.7529; R2 = 0.8678	y = 0.0294x + 9.8313; R2 = 0.8193	y = 0.0315x + 9.8095; R2 = 0.76	y = 0.0133x + 10.02; R2 = 0.3282	y = 10.181; R2 = 0
Acidosis	y = 0.0237x + 9.81; R2 = 0.8544	y = 0.0187x + 9.8569; R2 = 0.7862	y = 0.0146x + 9.8992; R2 = 0.6566	y = 0.0159x + 9.8864; R2 = 0.6423	y = 0.0195x + 9.8441; R2 = 0.508	y = 0.0091x + 9.9697; R2 = 0.057

Previous research suggested that in order to notice postpartum complications as early as possible, it is worth assessing variation in milk production, milk conductivity, animal activity, and animal weight prior to occurrence of clinical symptoms (Antanaitis et al., 2012). Milk production can be considered as a supplementary diagnostic indicator of disorders commonly suffered by cows after calving (Antanaitis et al., 2010). Indicators recorded by the herd management software and assessed during the period of investigation are considered to serve as the diagnostic algorithm for ketosis and acidosis.

Conclusion

1. In cows sick with ketosis the **milk yield** had a tendency to decrease most significantly for the last 8 days of their clinical symptoms. On the day of disease detection, the **activity** was found to increase by 21.5 %, when compared to the day 12 before emergence of clinical symptoms ($p<0.0001$). However, this increase is the most pronounced 2 days before the detection of the disease (3.1–3.7 %; $p<0.001$). The major increase in milk **conductivity** was observed 2 days before the emergence of clinical symptoms of the disease (3.1–3.7 %; $p<0.001$).

2. In cows sick whit acidosis the **milk yield** tended to decrease most significantly for 6 days ($p<0.01$) before emergence of their clinical symptoms. The variation of animal **activity** in the period under research was diverse. Its significant increase was observed 2 days before emergence of clinical symptoms ($y = 2.9x + 20.667$; $R2 = 0.839$). Starting with days 6–7 before detection of disorders under consideration, a gradual increase in milk **conductivity** was observed.

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