**Науковий вісник Львівського національного університету
ветеринарної медицини та біотехнологій імені С.З. Гжицького.**
Серія: Ветеринарні науки

**Scientific Messenger of Lviv National University
of Veterinary Medicine and Biotechnologies.**
Series: Veterinary sciences

ISSN 2518–7554 print
ISSN 2518–1327 online

doi: 10.32718/nvlvet9501
<http://nvlvet.com.ua>

UDC 619:612.014.2:618.19–002

Immunobiological aspects of cow lactation

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Article info

Received 27.08.2019
Received in revised form
26.09.2019
Accepted 27.09.2019

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Zhelavskiy, M.M. (2019). Immunobiological aspects of cow lactation. Scientific Messenger of Lviv National University of Veterinary Medicine and Biotechnologies. Series: Veterinary sciences, 21(95), 3–8. doi: 10.32718/nvlvet9501

Lactation of cows is a high-energy metabolic process. It is regulated in the body by the complex physiological mechanisms of the nervous, endocrine and immune systems. The purpose of to study changes in the immunobiological reactivity of the body of cows during lactation. Clinical and experimental studies were accomplished at the veterinary clinic and in the specialized laboratory of reproductive animal immunology. For the study, four groups of analogues of experimental animals were formed in which the immunological methods determined the immune status: cows ($n = 17$) during the early lactation (secretion of colostrum, 3–5th day); second ($n = 32$) – cows ($n = 32$) in the mid (3–5th month) lactation; the third ($n = 28$) – during the late lactation (5–7th day) and the fourth group ($n = 28$) – during the dry period (12–20th day). Our research has shown that during lactation in the body of cows fluctuations of the studied indicators of cellular and humoral immunity occur. Experimental data that showed that the percentage of T-lymphocytes in the blood of cows of Ukrainian dairy black-billed breed during the initial (3–5 days) period of lactogenesis is the lowest ($37.88 \pm 1.53\%$). However, the lowest expression of B-immune cells ($16.05 \pm 0.74\%$) was also detected during colostrum secretion. These changes occurred against the background of the decrease in $CD3^+/CD22^+$ (2.36 ± 0.11). In particular, at the 3–5th month of lactation, peripheral blood flow contained $53.40 \pm 0.83\%$ $CD3^+$, ie 1.40 times more. The number of $CD22^+$ mononuclear cells increased by only 1.14 times (up to $18.31 \pm 0.69\%$). The beginning late lactation and dry period in the number of immunocompetent cells was observed: $CD3^+$ – up to $42.11 \pm 1.03\%$, and $CD22^+$ – up to $22.92 \pm 0.89\%$. All this was accompanied by a corresponding redistribution of the balance ($CD3^+/CD22^+$). We have identified certain patterns in the blast transformation ability of T-lymphocytes, which was manifested in the change in the activity of activated immune cells of blood. At the beginning of lactation, the functional capacity of T cells was the lowest ($42.47 \pm 0.62\%$). But subsequently with the increase of the lactation curve there was a certain activation of their transformation into blasts ($51.11 \pm 1.05\%$). At the beginning of late lactation cows underwent a gradual decrease in the blasttransformation capacity of immunocompetent cells ($43.11 \pm 0.89\%$). And which continued to decline gradually during the dry period. Thus, during lactation in the body of cows there are dynamic permanent changes in the system of cellular and humoral immunity. From the beginning of lactogenesis, there is a gradual increase in the increase in the functioning of the mammary gland of cows, and further decrease in the population composition of $CD3^+$ and $CD22^+$, which was also accompanied by changes in the functional activity of immunocompetent cells.

Key words: cows, lactation, immune status, immunocompetent cells, parameters of immunity.

Introduction

Lactation of cows is a high-energy metabolic process. It is regulated in the body by the complex physiological mechanisms of the nervous, endocrine and immune systems (Blum et al., 2015; Kempf et al., 2016; Law et al., 2017). To date, the biochemical and cytological parameters of the secretion of the mammary gland of cows have already been comprehensively studied. Along

with this, the immune mechanisms of protecting the local immunity of the udder during various periods of lactation are not yet sufficiently illuminated (Lombardini et al., 2017; Mann et al., 2019). Among the many modern research methods, researchers focus on applied methods of clinical immunology. New scientific developments reveal new information about the mechanisms of immune defense in various periods of lactation (Zhelavskiy, 2018; Mezzetti et al., 2019). This is important in determining

the diagnostic criteria for immunological disorders (Yablonskyi & Zhelavskyi, 2009; Al-Farha et al., 2017).

The system of cellular defense factors includes lymphocytes, macrophages, natural killers (NK) (Call et al., 2008; Abebe et al., 2016; Cao, et al., 2018). It was determined that the total number and population composition of these cells in milk has species and breed features, and also depends on the physiological state of the mammary gland (Herry et al., 2017; Delfani et al., 2017). The parameters of systemic immunity also change (Yablonskyi & Zhelavskyi, 2005; Yablonskyi & Zhelavskyi, 2007; Yablonskyi & Zhelavskyi, 2008; Yablonskyi & Zhelavskyi, 2009; Tizard, 2013; Zarrin et al., 2014; Hine et al., 2019).

The purpose of to study changes in the immunobiological reactivity of the body of cows during lactation.

Material and methods

The research was carried out on cows of Ukrainian black-and-white milk breeding at the farms of the Khmelnytsky region and in the specialized laboratory of immunology of reproduction of mammals of the Faculty of Veterinary Medicine of the State Agrarian and Engendering University in Podilya. At the initial stage, the ontogenetic features of the onset of local immunity of the breast of primary cows were studied.

Animals' criteria. Clinical and experimental studies were accomplished at the veterinary clinic and in the specialized laboratory of reproductive animal immunology. For the study, four groups of analogues of experimental animals were formed in which the immunological methods determined the immune status: cows (n = 17) during the early lactation (secretion of colostrum, 3–5th day); second (n = 32) – cows (n = 32) in the mid (3–5th month) lactation; the third (n = 28) – during the late lactation (5–7th day) and the fourth group (n = 28) – during the dry period (12–20th day).

The immune status of the cows was determined using the developed immunocard, which included a step-by-step

determination of indices of nonspecific resistance and specific immunobiological reactivity (CD3⁺, CD22⁺) (Yablonskyi & Zhelavskyi, 2014).

This study was approved according to the Law of Ukraine “On the Protection of Animals from Cruel Treatment” (No. 3447-IV of February 21, 2006) and according to the requirements of the European Convention for the Protection of Pet Animals (ETS No.125, Strasbourg, 13/11/1987). All experiments were carried out with the Ethical Permit at the State Agrarian and Engineering University in Podilya, Ukraine. All animal manipulations were performed in accordance with the European Convention for the Protection of Vertebrate Animals used for experimental and scientific purposes (Strasbourg, 18 March 1986).

The values in this study are presented as mean ± SD. The data in this study are given as the mean ± SD. Data were analyzed by one-way analysis of variance (MANOVA). Differences were considered statistically significant at a P-value of less than 0.05. Biometric analysis and interpretation of the obtained results were performed using statistical software Statistica v. 12.

Results and discussion

The most informative in clinical immunology in determining the immune status of the organism is to determine the population composition of immunocompetent cells in peripheral blood, namely: T-, B- and O-lymphocytes.

Our research has shown that during lactation in the body of cows fluctuations of the studied indicators of cellular and humoral immunity occur. Shows (Table 1) experimental data that showed that the percentage of T-lymphocytes in the blood of cows of Ukrainian dairy black-billed breed during the initial (3–5 days) period of lactogenesis is the lowest (37.88 ± 1.53%). However, the lowest expression of B-immune cells (16.05 ± 0.74%) was also detected during colostrum secretion. These changes occurred against the background of the decrease in CD3⁺/CD22⁺ (2.36 ± 0.11).

Table 1

Indicators of the immune status of experimental cows in different periods of breast function (M ± m)

Components'	Lactation periods			
	Early lactation (n = 17)	Mid lactation (n = 32)	Late lactation (n = 28)	Dry period (n = 28)
CD3 ⁺ , %	37.88 ± 1.53	53.40 ± 0.83 ▲	47.19 ± 0.78 ◇	42.11 ± 1.03 ◇
CD22 ⁺ , %	16.05 ± 0.74	18.31 ± 0.69 ◇	23.84 ± 0.73	22.92 ± 0.89
CD3 ⁺ /CD22 ⁺	2.36 ± 0.11	2.92 ± 0.11 ◇	1.97 ± 0.07 ◇	1.83 ± 0.05 ◇

Notes: * – P < 0.05; ◇ – P < 0.01; ▲ – P < 0.001 – relative to indicators of the early of lactation

Subsequently, with the increase in milk productivity, there was an increase in the number of differentiated immunocompetent cells. In particular, at the 3–5th month of lactation, peripheral blood flow contained 53.40 ± 0.83% CD3⁺, ie 1.40 times more. The number of CD22⁺ mononuclear cells increased by only 1.14 times (up to 18.31 ± 0.69%). The number of O-lymphocytes decreased by 1.62 – fold at this time and amounted to only 28.28 ± 1.11% of the total lymphocyte population. With

the extinction of lactation, at the beginning late lactation and dry period in the number of immunocompetent cells was observed: CD3⁺ – up to 42.11 ± 1.03%, and CD22⁺ – up to 22.92 ± 0.89%. All this was accompanied by a corresponding redistribution of the balance (CD3⁺/CD22⁺).

The functional activity of T-mononuclear cells also changed during the lactation of cows. We have identified certain patterns in the blast transformation ability of T-

lymphocytes, which was manifested in the change in the activity of activated immune cells of blood. At the beginning of lactation, the functional capacity of T cells was the lowest ($42.47 \pm 0.62\%$). But subsequently with the increase of the lactation curve there was a certain activation of their transformation into blasts ($51.11 \pm 1.05\%$). And already at the beginning of late lactation cows underwent a gradual decrease in the blasttransformation capacity of immunocompetent cells ($43.11 \pm 0.89\%$). And which continued to decline gradually during the dry period.

The organism of animal is a complex biological self-replicating self-regulatory system that has adapted during evolution to exist in relatively unstable environmental conditions. In the course of long phylogeny in mammals, clear mechanisms of interaction between microorganisms and the organism of animals and humans were formed, and the immune protection system was evolved, and immunity was formed (Ceniti et al., 2017; Ding et al., 2019). In the modern sense of immunity means the ability of the body to protect itself from genetically extraneous (as well as other pathogenic factors), aimed at maintaining biological homeostasis (Kurjogi & Kaliwal, 2014; Günther et al., 2017; Zhelavskiy, 2018). The stability of the internal environment of an organism depends on its reactivity and ability to counteract the harmful environmental factors (Zhelavskiy, 2010; Zhelavskiy, 2014; Zhelavskiy, 2015; Zhelavskiy, 2017).

Immunobiological protection of the body is provided by a system of organs, tissues and cells that interact with pathogenic factors: bacteria, viruses, mycoplasmas, rickettsiae, fungi, parasites and ensure their destruction and elimination from the body. At the same time, the immune system carries out censorship control in the body – recognizes and neutralizes moused, invaded, apoptotic cells and cells with signs of oncogenic transformation (Vernay et al., 2012; Tizard, 2013; Kurjogi & Kaliwal, 2014; Pang et al., 2017; Ruegg, 2017).

Immunobiological aspects of animal lactation have been studied by scientists in many countries. we have shown that fluctuations in the parameters of specific immunobiological protection occur throughout the period of lactogenesis. similar studies were obtained in studies (Singh et al., 2011; Thompson-Crispi et al., 2014; Ndhlovu & Masika, 2017; Sato et al., 2017; Powell et al., 2018; Piñeiro et al., 2019). We have shown that during lactation in the body of cows, both quantitative changes in the population of immunocompetent cells and changes in their functional activity occur (Zhelavskiy & Shunin, 2017; Zhelavskiy, 2017; Zhelavskiy & Dmytriv, 2018; Zhelavskiy, 2018; Zhelavskiy et al., 2019).

Conclusions

During lactation in the body of cows there are dynamic permanent changes in the system of cellular and humoral immunity. From the beginning of lactogenesis, there is a gradual increase in the increase in the functioning of the mammary gland of cows, and further decrease in the population composition of

CD3⁺ and CD22⁺, which was also accompanied by changes in the functional activity of immunocompetent cells.

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