Problems of Breeding and Husbandry in High-Performance Dairy Herds

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The main challenges faced in modern high-performance dairy herds include:

- Deterioration in reproductive indicators and a decrease in the productive lifespan of cows as a primary consequence of increasing milk yield.
- Extension of the lactation period.
- Widespread problems with mastitis (inflammation of the mammary gland) and the negative impact of these conditions on both production volume and the technological quality of milk.
- Difficulties in balancing nutritional rations – leading to excessive urea levels in milk.
- Ketosis as a major consequence of negative energy balance in dairy cows.
- Transition to free-market (a non-quota) system – moving away from milk production quotas (limiting production).
- The need to optimize the chemical composition of milk and further improve its hygienic quality.

Deterioration of reproductive indicators and decrease in the productive lifespan of cows

An analysis of changes in the average milk yield (kg) for a 305-day lactation period and the length of the intercalving period (days) in cows assessed in Poland from 1980 to 2023 revealed that the average milk yield for a 305-day lactation increased from 3,297 kg in 1980 to 9,150 kg in 2023. At the same time, the average length of the intercalving period increased from 389 to 420 days. Over the past 43 years in Poland, an increase in milk yield by 189 kg per 305-day lactation period was associated with an extension of the intercalving period by 1 day. These data indicate a negative correlation between milk yield and the length of the intercalving periods. The increase in milk yield from cows should be regarded as a primary factor limiting their reproductive efficiency.

The natural lifespan of cows is about 20 years, meaning that a cow can potentially produce milk in 15-17 lactations. However, due to the increase in individual milk yield, the potential lifespan of cows from high-producing breeds in modern dairy herds has significantly shortened. Currently, the longevity of cows, defined as the age at culling, is 5.8 years in the Netherlands (2021), about 5 years in the USA (2023), and 5.7 years in Poland.

Extension of the milk production period (lactation)

From the perspective of the length of the milk production period, i.e., lactation, there are two main systems worldwide: the traditional system and the extended lactation system. In the traditional production system, the standard length of lactation is 305 days, or approximately 10 months. In the extended lactation production system, the average length of lactation is extended to around 390 days.

In the extended lactation system, dairy cows calve not every 12 months as in the traditional system, but approximately every 18 months. This system replaces three 12-month production cycles with two 18-month cycles. Currently, 55% of cows in Poland produce milk under the extended lactation system.

Mastitis and its negative impact on milk production and composition

Due to the fact that cow's milk is produced under specific conditions, one of which is the microbial environment, there are numerous issues within dairy herds arising from the infiltration of bacteria into the milk within the cows' mammary glands. These bacteria can cause inflammatory conditions collectively known as mastitis. Therefore, maintaining high hygienic and cytological quality of milk from cows is a daily challenge for dairy farmers both domestically and globally. This task can be compared to "Sisyphean labor," referring to a difficult, monotonous, and persistent effort that never fully achieves complete success.

The presence of microorganisms in milk leads to the appearance of somatic cells, which are a key part of the animal's immune response. As a result, somatic cells are considered the primary criterion for assessing the health status of the mammary glands and the cytological quality of milk. The number of somatic cells is commonly regarded as an indicator of the health of dairy cows' udders. It is also an important criterion in milk collection centers. In Poland and the European Union, milk with a somatic cell count of <400,000/ml is accepted, while in the USA, the threshold is <750,000/ml. An increased number of somatic cells has significant consequences, including a decrease in milk yield (up to 12% in subclinical cases) and unfavorable changes in its chemical composition.

Mastitis represents a significant economic problem both domestically and globally. The economic losses in Poland amount to approximately 1 billion PLN annually. Scientific studies indicate that in Poland, at least 30-40% of cows experience some form of mastitis (both clinical and subclinical) during a single lactation. It is widely accepted that 25% of all cows removed from herds due to culling are culled because of incurable mastitis.

Difficulties in balancing nutritional rations – the appearance of excess urea in milk

The presence of urea in cow's milk results from the nature of metabolic processes in the digestive tract, which lead to an excess of undigested ammonia in the body that was not broken down by microorganisms. This highly toxic compound is detoxified in the liver and converted into urea. The primary cause of excessive urea levels in milk is an excess of protein in the feed rations and their imbalance in terms of energy and protein content. A number of factors influence the urea level in milk in a production environment, including: the frequency of feedings, the number of milkings, the length of the interval between milkings, the cows' body weight, water intake, the level of Na and K supplementation in the feed rations, and the pH of the rumen.

In modern zootechnical knowledge, information on urea concentration in milk from dairy cows is used to assess the energy-to-protein balance of the rations, reduce feed costs, and can also serve as a biomarker to estimate the potential for reducing nitrogen (N) emissions into the environment.

The most important factor in assessing the level of urea in milk is the evaluation of protein levels in the cows' feed rations. Increasing the share of true protein in the dry matter of the ration from 13% to 18% leads to an increase in the concentration of urea in milk from 70 to over 150 mg per liter. Available scientific studies also indicate that urea concentration in milk increases with higher daily milk yields in cows.

The ultimate goal of assessing urea levels in milk is its practical use in evaluating the balance of feed rations by identifying cows whose milk falls within specific urea concentration ranges (as a biomarker for protein levels in the feed rations) and milk protein (as a biomarker for energy levels in the feed rations). Based on the data cited in the presentation, it can be concluded that in Poland, 56.3% of milk samples met the criteria for balanced protein requirements, while only 35.0% met the criteria for balanced energy requirements.

An important aspect of using information about urea levels in milk is the potential for reducing nitrogen excretion by dairy cattle. This issue is particularly significant due to concerns about agriculture's contribution to environmental pollution with nitrogen compounds, especially ammonia emissions into the atmosphere. In a dairy farm, the primary source of ammonia is the nitrogen contained in the urea of manure and urine, which hydrolyzes into ammonia and carbon dioxide. In this way, a well-fed cow emits approximately 40 kg of ammonia into the atmosphere annually. In Poland, the total annual ammonia emission is around 386,000 tons, with cattle contributing about 155,000 tons. An increase in urea concentration in milk from levels below 150 mg/L to above 300 mg/L is associated with an increase in ammonia emissions from 32.3 to 57.7 kg per year per cow.

One practical solution to the problem of ammonia emissions from dairy herds is the use of cow toilets. The goal of this approach is to separate urine from fecal enzymes that convert urea into ammonia. Whether cows will accept this solution remains to be seen in the future.

Consequences of negative energy balance in dairy cows: ketosis and ketone bodies in milk

In high-performance dairy cows, a state of energy deficiency occurs during the first 8-10 weeks of lactation. To counteract this, the animal's body mobilizes stored fat reserves. As a result, fatty acid levels in the blood of cows can increase by up to 10 times. When the level of carbohydrates (glucose) in the blood is insufficient, the incomplete burning of free fatty acids occurs, leading to the appearance of ketone bodies in the blood, urine, and milk of cows.

During periods of energy deficit, cows use the subcutaneous fat reserves accumulated during the dry period, which is a natural mechanism to meet the cows' energy needs. A cow with a body condition score of 3.5 at calving will experience a reduction in body weight of about 0.5–1 kg per day during the first 60–80 days of lactation. For this reason, evaluating the condition of cows is considered an important factor in preventing the consequences of energy deficiency in dairy rations.

When energy needs are unbalanced, it results in a negative energy balance and the occurrence of a metabolic disease known as ketosis. Ketosis is one of the most significant metabolic disorders in dairy herds, including in Poland. It is a typical "occupational disease" of high-performing dairy cows. The main symptoms of ketosis include an atypical increase in milk fat levels (above 5%) alongside a decrease in protein levels (below 2.9%). The fat-to-protein ratio is elevated to over 1:1.4. Ketosis leads to a significant decrease in milk yield, negatively affects reproductive performance, and impairs the cows' resistance to infectious diseases such as mastitis and endometritis. On average, ketosis affects 7–14% of cows in a herd, with the incidence potentially reaching 50% in high-yielding herds.

Departure from milk quota system and transition to free-market competition

Since the great bourgeois revolution in France and the overthrow of the feudal system (1789), the capitalist socio-economic system has emerged worldwide. Capitalist socio-economic relations are based on three main principles of conducting business, namely:

1. Private ownership of the means of production
2. Profit maximization

3. Market competition as a method of determining production levels and prices

In cattle breeding and milk production, the capitalist economic system has been in place in Poland and EU countries since 2015. The last year of milk quotas was 2014/2015, after which the milk market opened up to the mechanisms of market competition. What does this mean for the dairy sector in the country? It means competition based on capitalist mechanisms of regulating production, which depend on production scale and production costs (economies of scale). These factors give an advantage to large milk producers. In the future, the free-market system will likely lead to a reduction in the number of producers – ideally to the smallest possible number.

Optimization of milk's chemical composition and further improvement of its hygienic quality

The chemical composition of cow's milk is not constant. The variability in the content of the main milk components in cows kept in the conditions of Southern Podlasie, measured by the coefficient of variation, for fat, protein, lactose, and urea was 19.5%, 13.8%, 5.3%, and 48.6%, respectively.

Modifying the chemical composition of milk is the result of various factors that consistently differentiate the levels of its components at the production level. In the domestic context, these factors include: the season of the year, the age of the cow, the stage of lactation and pregnancy, body condition during milk production, diseases (primarily metabolic and udder-related), and the applied feeding technologies.

From a health-oriented perspective, in the future, the following modifications to milk's composition should be considered: ensuring a low omega-6 to omega-3 fatty acid ratio, which should be around 2:1; increasing the share of oleic acid to 25-30% of milk fat at the expense of palmitic acid; increasing the proportion of A2 beta-casein in milk; increasing the concentration of conjugated linoleic acid (CLA); increasing selenium levels in milk; and maintaining a stable level of iodine.

The A2 milk issue

One of the primary fractions of the most important milk protein in cows, casein, specifically β-casein, has two genetic variants, known as alleles A1 and A2. The A1 and A2 beta-casein molecules are essentially identical, differing only by one of the 209 amino acids. At position 67 in the protein chain, the A2 variant has proline, while the "mutant" A1 variant has histidine. The spatial structure of A1 casein prevents its full digestion into individual amino acids. The digestion of A1 casein leads to the formation of a peptide called beta-casomorphin-

7 (BCM7) in the human stomach. Beta-casomorphin is an opioid, similar to morphine or heroin. Therefore, the consumption of A1 casein may be associated with a higher risk of common lifestyle diseases.

The A2 casein variant is widespread in nature and is the only form of β-casein found in almost all mammals. Unfortunately, in cattle, very few breeds have exclusively A2 genes, leading to the production of only A2 casein. Breeds of cattle with this desirable genotype are most commonly found in developing countries, primarily in Asia and Africa. Cattle breeds raised in Poland and other highly developed countries typically have the A1/A1 genotype, producing only A1 casein, or the A1/A2 genotype, with equal amounts of A1 and A2 casein in their milk.

For these reasons, there is a global effort to select cows that produce milk containing only A2 casein. One of the pioneering countries in this regard is Australia, where A2 milk already accounts for 12% of the country's liquid milk market. A2 milk is also becoming more widely available on the European market.

Summary

In summary, the most significant challenges in dairy herds include: a reduction in the productive lifespan of cows and declining reproductive performance, prolonged lactation periods, udder inflammations, the appearance of excessive urea levels in milk, the occurrence of ketosis and ketone bodies in milk, the transition to a free-market system and the resulting increase in unit milk yield as a primary condition for success in the competitive milk market, and the need to optimize the chemical composition of milk.

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