Szkoła Główna Gospodarstwa Wiejskiego

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Wpływ wybranych czynników genetycznych i fizjologicznych na cechy użytkowości mlecznej i mięsnej bydła, ze szczególnym uwzględnieniem zmian o charakterze antyoksydacyjnym

Influence of selected genetic and physiological factors on milk and meat performance traits in cattle, with particular reference to antioxidant changes

Rozprawa doktorska

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Summary

The dissertation consists of six published and thematically related scientific articles. The aim of the dissertation was to evaluate the effects of energy deficit, crossbreeding strategies and calf rearing systems on antioxidant properties and oxidative stability of milk and meat in relation to reducing the effects of inbreeding in the Polish Holstein-Friesian (PHF) cattle population.

High milk production in cows has been a priority in breeding programs for many years, resulting in significant genetic progress in production traits. Nevertheless, achieving high genetic potential is associated with increasing physiological demands on animals, especially during the transition period. During this crucial period, which includes the time before parturition and in the early stages of lactation, cows are often unable to meet their energy requirements from feed. Energy deficiency forces the body to mobilize endogenous reserves, which promotes the development of ketosis - a metabolic disorder that often initiates a cascade of subsequent health problems. The widespread occurrence of such conditions is the result of long-term selection for improved production traits, including the use of only animals with the highest breeding value in reproduction. The high level of crossbreeding in the PHF population has led to a reduction in genetic variability and a weakening of functional traits, including milk yield and milk quality, especially protein and fat content. An alternative to reduce or completely eliminate the effects of crossbreeding is the use of crossbreeding, especially the occurrence of the crossbreeding-related heterosis effect. The occurrence of this phenomenon brings benefits related to an increase in the value of traits, especially low-inbreeding functional traits, thus directly affecting the quality of the milk obtained. Crossbreeding can also be used to increase meat quality in dairy herds through the use of commodity crossbreeding, where HF cows are covered with semen from specialized meat breeds. Despite the benefits related to the use of crossbreeding, the breeding of purebred animals, which should be the basis of breeding, should not be completely eliminated. The potential of this breed can be used to produce high-quality veal through proper nutrition and improved welfare.

The purpose of experiment one was to determine the effect of energy deficit on the lipid profile of cows' milk. The study analyzed milk and blood samples from 55 multiparous and 50 primiparous cows, which were divided into a group of healthy animals and a group of cows diagnosed with ketosis. A total of 315 milk samples (three times from each cow at weekly intervals, starting on the 5th ± 2 days after parturition) and 105

blood samples (on the 5th ± 2 days after parturition) were collected. The milk samples were analyzed for basal composition and fatty acid profile, while β-hydroxybutyric acid (BHBA) concentration was determined in blood samples. The results of the study showed that energy deficit during the early lactation period significantly reduced the biosynthesis of long-chain fatty acids, including isomers of conjugated linoleic acid dienes (CLA). Reduced levels of CLA in the milk of energy-deficient cows indicated changes in the activity of enzymes responsible for synthesis, including delta-9-desaturase. The results obtained in experiment one supported the hypothesis that energy deficit affects the reduction of CLA synthesis, leading to changes in the lipid profile of milk.

The purpose of experiment two was to study the effect of crossbreeding between breeds on milk performance parameters. The study analyzed milk from 50 Polish Holstein-Friesian (PHF) cows and 50 PHF×SRB (Swedish Red) hybrids. Milk samples were taken ten times during lactation, starting from the first month after calving, which allowed a total of 1,000 samples to be collected. The basic chemical composition of the milk and the number of somatic cells were analyzed in the milk. The study showed significant differences in yield and levels of milk functional parameters. PHF×SRB hybrids had higher fat, protein, and dry matter contents compared to purebred PHF cows, suggesting a favourable effect of the SRB breed on milk quality. The higher fat, protein, and dry matter content in the milk of PHF×SRB hybrids may be due to their adaptability to changing environmental conditions and better tolerance to oxidative stress characteristic of the early lactation period. The results of the study support the hypothesis that crossbreeding has a positive effect on milk quality and chemical composition while highlighting the potential benefits of its use in breeding practice. The data obtained indicate that crossbreeding can be an effective tool for improving milk performance under intensive production conditions.

In experiment three, the goal was to determine the effect of crossbreeding on the antioxidant properties and oxidative stability of milk. The experiment selected 60 cows divided into two groups: 30 PHF cows and 30 PHF × SRB crossbred hybrid cows. A total of 600 milk and blood samples each were taken from the animals, which were collected on the same day, 10 times during lactation, from 5±2 days to 280 ±5 days of lactation. In the study conducted, the basic chemical composition, whey protein content, and fatty acid profile were determined in milk. Metabolic profile and total antioxidant potential (TAS) were analyzed in blood samples. The results of the experiment showed higher oxidative stability of milk in PHF×SRB hybrids compared to purebred cows. The increased activity

of antioxidant enzymes in the PHF×SRB hybrid group may be the result of favourable adaptive mechanisms, including efficient detoxification of free radicals and reduced susceptibility to oxidative damage. The results support the hypothesis that crossbreeding has a beneficial effect on the oxidative stability of milk and the antioxidant capacity of the organism.

The purpose of the fourth experiment was to study the effect of genotype and age at first calving on selected reproductive parameters, metabolic profile, and milk fatty acid composition. Sixty cows were selected for analysis, including 30 individuals of the Polish Holstein-Friesian (PHF) breed and 30 F_1 hybrids (PHF×SRB - Swedish Red). The animals were divided into groups according to the age of first calving: under 24 months and over 24 months. Each of the four groups consisted of 15 cows. On the 35th ± 5th day of lactation, milk and blood samples were taken. Basic composition and fatty acid profile analyses were performed in the milk, while metabolic parameters, including energy balance indices, were determined in the blood samples. In addition, reproductive parameters such as the length of the inter-pregnancy period, the mating rate and the length of the inter-breeding period were analyzed on the basis of breeding records. The results showed that F_1 hybrids were characterized by higher metabolic stability and less susceptibility to the occurrence of negative energy balance during the early lactation period compared to purebred PHF cows. The ability to use energy efficiently during the early lactation period may influence higher milk yields and a more favourable fatty acid profile. In addition, better metabolic adaptation may translate into more favourable reproductive parameters, including a shorter inter-pregnancy period and higher insemination efficiency. These results confirm the benefits of crossbreeding, which contributes to improved production efficiency and animal health in intensive breeding systems.

The purpose of experiment five was to determine the effect of genotype on the antioxidant potential of muscle tissue of bulls of the Polish Holstein-Friesian (PHF), Limousin (LM) and PHF×LM crossbred hybrids. Sixty-two bulls were selected for the study, including 12 individuals of the PHF breed, 25 of the LM breed and 25 of the PHF×LM hybrids. After slaughter, muscle tissue samples were taken from the semimembranosus muscle, which was then analyzed for basal composition, fatty acid profile, bioactive protein content and fat-soluble vitamins. The results confirmed the hypothesis of a higher content of bioactive components, including omega-3 fatty acids, and a higher activity of antioxidant enzymes in the muscle tissue of PHF×LM hybrid bulls

compared to purebred animals. The increased activity of antioxidant enzymes in the muscles of F_1 hybrids indicates the beneficial effects of commodity crossbreeding in terms of improving defense mechanisms against oxidative stress. Increased activity of the antioxidant system in muscle tissue may indicate improved protection against oxidative damage, which may consequently improve meat quality, shelf life and nutritional properties, including reduced lipid oxidation, which is beneficial to the sensory quality and health-promoting values of the product. These results confirm that crossbreeding between PHF and LM breeds can be an effective breeding strategy for improving meat quality by increasing antioxidant potential and protection against oxidative stress.

The purpose of the latest experiment was to determine the effect of the rearing system on shaping the antioxidant potential of calf muscle tissue. Two groups of 15 calves each were selected for the study. The first group was kept in pens where milk was taken by the calves from automatic machines equipped with a teat, while the second group was reared by foster cows. During the experiment, the health of the calves was monitored based on observations by a veterinarian, their behaviour was evaluated, and weight gains were recorded. At the end of the 6-month rearing period, the calves were slaughtered, and muscle tissue samples were taken from the semimembranosus muscle. The samples were used to determine the basic composition, fatty acid content, myoglobulin, malondialdehyde (MDA) and meat colour. The results of the experiment showed that calves reared by sucklers had better resistance to oxidative stress, fewer health problems and higher weight gains compared to calves kept in pens. The system of rearing calves under natural conditions with a mom promoted better development of protection mechanisms against oxidative stress, which translated into more favorable fatty acid composition in muscle tissue and better meat quality. Higher activity of antioxidant enzymes and lower levels of MDA were observed in the muscle tissue of calves reared by mothers, suggesting less oxidative damage. The results support the hypothesis that the rearing system has a significant effect on shaping the antioxidant potential of calf muscle tissue, as well as on the oxidative stability of meat. Optimizing the calf rearing system to minimize oxidative stress may be important for improving meat quality, nutritional value and shelf life.

Key words: cattle, genetic factors, physiological factors, dairy performance, meat performance, antioxidant potential