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# Application of robotics in automation of livestock feeding and farm management

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**Abstract**. The study aimed to assess the impact of automated feeding on the physiological state, productivity and conditions of livestock. The study analysed the effect of automated feeding systems on physiological parameters, stress levels, cattle productivity and sanitary conditions in the feeding area. The experiment was conducted on 200 dairy cows and 150 beef bulls, divided into control (traditional feeding) and experimental (automated feeding) groups. Body temperature, heart and respiratory rates, stress levels, disease incidence, milk yield, average daily weight gain and microclimate parameters were measured. The study results demonstrated that the

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body temperature in the experimental group was 0.3°C lower (38.6°C vs. 38.9°C in the control group), the heart rate decreased by 9% (60 ± 3 beats/min vs. 66 ± 4 beats/min), and the respiratory rate by 14.3% (24 ± 2 breaths/min vs. 28 ± 3 breaths/min). Stress levels, as measured by cortisol, decreased by 29.4% compared to traditional feeding. The incidence of gastrointestinal disorders decreased from 22.5% to 9.5%, and cases of metabolic disorders from 13.2% to 6.7%. Milk yields in the automated system increased by 19.1% (26.8 ± 1.1 litres/day vs. 22.5 ± 1.2 litres/day), and average daily weight gain in beef cattle increased by 23.2% (1.38 ± 0.05 kg/day vs. 1.12 ± 0.07 kg/day). The analysis of the microclimate in the feeding area determined a 22% reduction in ammonia levels, an improvement in humidity to the optimum 65-70% and a 17% increase in the cleanliness of the feeders. Comparisons with European farms demonstrated that automated feeding can reduce the gap between Ukrainian farms regarding animal productivity and sanitary conditions. The findings confirm the feasibility of introducing automated feeding systems to reduce morbidity, increase feeding efficiency and create more comfortable conditions for cattle

**Keywords:** physiological state; sanitary conditions; technological innovations; feed efficiency; feed management

## INTRODUCTION

The research relevance is determined by the need to increase the efficiency of livestock production in Ukraine through the introduction of modern automated feeding technologies. The use of such systems can improve the physiological condition of animals, reduce stress, optimise the diet and increase the productivity of cattle. In developed countries, such as Germany, the Netherlands and Denmark, automated systems are actively used to ensure stable growth in milk yields and average daily weight gain. In Ukraine, the level of adoption of these technologies remains insufficient, which affects the efficiency of livestock farming and the conditions of livestock keeping. The problem of the study is that traditional methods of animal feeding often do not meet modern requirements for production efficiency. Uneven distribution of feed, high incidence of diseases, low productivity, and high levels of stress in animals are key challenges that can be addressed through automation. Insufficient adaptation of Ukrainian farms to the latest technologies makes it difficult to maintain optimal physiological parameters of animals and reduces their productivity (Misiuk & Zakhodym, 2023). Therefore, research into the impact of automated feeding systems on the health and productivity of cattle is necessary for the implementation of effective feeding management methods and the improvement of animal welfare in Ukraine.

According to a study by D. Chebotar (2024), artificial intelligence is substantial in optimising production processes in livestock farming, which reduces human intervention and improves feeding efficiency. Similar conclusions were drawn by O. Solona *et al.* (2023), proving the effectiveness of digital technologies in livestock production, emphasising their positive impact on the physiological state of animals and dietary stability. As noted by P. Lub *et al.* (2024), the use of information technology in agriculture contributes to better resource management, which has a direct impact on feeding efficiency and livestock comfort. At the same time, according to H. Dilaver and K.F. Dilaver (2024), the introduction of robotic systems in livestock production provides a stable feeding regime and reduces stress in animals, which has a positive effect on their productivity. A. Monteiro *et al.* (2021) investigated the principles of precision agriculture, including automated livestock management, and noted that the use of such technologies helps to increase animal productivity through optimal feed supply. Furthermore, A. Melak *et al.* (2024) analysed the impact of artificial intelligence on farm management, which increased the efficiency of automated feeding systems and optimised production processes.

Moreover, C. Tzanidakis *et al.* (2023) addressed the possibilities of using precision animal husbandry technologies for the maintenance of pasture animals, which increased the efficiency of feed distribution and reduced feed losses. In turn, D.E. Micle *et al.* (2021) investigated the impact of robotic process automation on dairy farming efficiency, emphasising the increase in productivity due to intelligent control systems. Furthermore, according to G.O. Uzedhe *et al.* (2023), the introduction of automated feeding systems reduced animal stress and improved sanitary conditions in the feeding area, which positively affected the overall productivity of livestock. At the same time, E. Romano *et al.* (2023) analysed the benefits of automated feeding systems at the farm level in Italy, highlighting the improvement of physiological parameters in cattle.

According to the analysis of R. García *et al.* (2023), autonomous computing systems are key in livestock production processes, providing stable feeding control and reducing dependence on the human factor. In addition, M. Dayoub *et al.* (2024) highlighted the prospects for the development of smart farming, where automated feeding systems are a key element in increasing productivity and improving animal welfare. Thus, the analysed studies confirmed the feasibility of automating cattle feeding as a tool for increasing productivity and improving animal health. The study aimed to assess the impact of automated feeding systems on the health and productivity of cattle and compare it with the practices of Germany, the Netherlands and Denmark.

## MATERIALS AND METHODS

The study was conducted in 2024 between June and August at the Agro-Leader farm in Kyiv region (Ukraine). The region is characterised by a temperate continental climate, which includes warm summers with average daily temperatures ranging from +18°C to +27°C, as well as sufficient humidity for intensive livestock farming. Precipitation in summer averages 200-250 mm, which helps to maintain the natural moisture content of the fodder. The farm was chosen due to its modern infrastructure, the ability to use automated feeding systems and the presence of a large number of dairy and beef cattle. The objects of the study were dairy cows (Ukrainian Black-and-White breed) and Limousin beef bulls. The choice of these categories of cattle was justified by the need to assess the impact of automated feeding on different areas of livestock production – dairy and meat. The dairy productivity of cows largely depends on the stability of feeding and the absence of stress factors, which could be improved through automation. In the case of beef breeds, efficient feed intake and uniform weight gain were the key indicators to be analysed.

The experiment included two groups of animals: control (traditional feeding) and experimental (automated feeding). Each group consisted of 200 dairy cows and 150 beef bulls. The animals' diet consisted of 35 kg of silage, 8 kg of haylage, 6 kg of mixed fodder and 1.5 kg of mineral supplements per day. In the control group, feeding was conducted manually twice a day (at 6:00 and 18:00), while in the experimental group, an automated system Trioliet Triomatic T40 (Netherlands) was used to ensure uniform feed distribution six times a day (at 5:00, 9:00, 13:00, 17:00, 21:00 and 1:00). The following devices were used to measure physiological parameters: a digital veterinary thermometer Gimette VT-10 (France) to measure body temperature, an electronic stethoscope 3M Littmann 3200 (USA) to record heart rate, a portable gas analyser Dräger X-am 5000 (Germany) to measure ammonia levels in the feeding area. The concentration of cortisol in the blood was determined using a Mindray MR-96A enzyme-linked immunosorbent assay (China). A 3M Clean-Trace ATP digital microbiological analyser (USA) was used to analyse the purity of the feeders. All experimental studies were conducted in accordance with European convention for the protection of vertebrate animals used for experimental and other scientific purposes (1986).

To evaluate the effectiveness of automated feeding, physiological parameters, disease incidence, stress level, productivity, and microclimate in the feeding area were analysed and the productivity of Ukrainian animals was compared with European farms. Physiological parameters included measuring body temperature using a Gimette VT-10 thermometer (France), heart rate using a 3M Littmann 3200 (USA) and respiratory rate by direct observation for one minute. The incidence of diseases was analysed based on veterinary reports of gastrointestinal disorders, metabolic disorders and hoof pathologies. The level of cortisol in the blood of animals was determined by enzyme-linked immunosorbent assay (ELISA) using a Mindray MR-96A device (China). Behavioural reactions of animals were assessed by observing the frequency of aggressive interactions during feeding, the average time of feed consumption and the duration of rest, which were recorded using a Hikvision DS-2CD2043G0-I video surveillance system (China) with automatic analysis of animal activity. The microclimate in the feeding area was assessed using a Dräger X-am 5000 gas analyser (Germany) to determine ammonia levels, a Testo 835-T1 digital thermometer (Germany) to measure air temperature, and an Extech RH390 hygrometer (USA) to determine humidity. Farms in Germany, the Netherlands, and Denmark were selected for the comparison of animal productivity, as these countries have a high level of livestock automation, which provided reliable results on the impact of technology on productivity. In addition, these countries have different approaches to livestock feeding, which provides a wider range for comparative analysis. Statistical processing of the results was conducted by analysis of variance (ANOVA) in Statistica 12 software using Student's t-test to assess the significance of differences between groups.

## RESULTS

**Influence of automated feeding on physiological parameters and disease incidence in cattle.** The body temperature of the animals receiving feed through the automated system fluctuated within the physiological norm (38.6 ± 0.2°C in cows and 38.7 ± 0.2°C in bulls). In the control group, greater deviations were recorded – 38.9 ± 0.3°C in cows and 39.0 ± 0.3°C in bulls. This indicates an increased thermal load on the animal body due to uneven feed intake, which is typical for traditional feeding methods. The heart rate of cows in the experimental group was 9% lower than in the control group (60 ± 3 beats/min vs. 66 ± 4 beats/min). This indicates a lower level of physiological stress and a general improvement in adaptation to the conditions of detention. Similarly, bulls in the control group had a heart rate of 70 ± 5 beats/min, while animals with automated feeding had a heart rate of 63 ± 3 beats/min. The respiratory rate was also lower in animals of the experimental group: 24 ± 2 breaths/min in cows and 27 ± 2 breaths/min in bulls, which is lower than in the control group (28 ± 3 breaths/min in cows and 32 ± 3 breaths/min in bulls). A decrease in respiratory rate may indicate a decrease in the stress load on animals, which is ensured by uniform feeding and better feeding organisation.

The level of cortisol in the blood – one of the key indicators of stress – was also different between the groups. In the control group, the average cortisol level was 5.1 ± 0.5 nmol/l, while in the experimental group,

it was 3.6 ± 0.4 nmol/l, which indicates a 29.4% reduction in stress. Limousin bulls have a similar trend: 5.4 ± 0.5 nmol/l in the control group and 4.0 ± 0.4 nmol/l in the experimental group. The frequency of nutrition-related diseases was significantly lower among the animals of the experimental group. Disorders of the gastrointestinal tract (GIT) in dairy cows of the control group were recorded in 22.5% of cases, including acidosis – in 12.1% of animals and diarrhoea – in 6.4%. In the experimental group, the frequency of such disorders decreased to 9.5%. In bulls, the incidence of gastrointestinal diseases was even higher – 25.8% in the control group versus 11.3% in the automated feeding animals. Hoof diseases were also much less common among the animals in the experimental group. In dairy cows of the traditional group, were recorded in 18.2% of cases, while in the experimental group – 7.8%. In bulls, these figures were 20.1% in the control group and 9.0% in animals fed through the automated system. Metabolic disorders, such as ketosis and hypocalcaemia, were also much less common in the experimental group. In cows in the traditional group, the incidence of these diseases was 13.2%, while in animals fed through the automated system, this figure dropped to 6.7%. In bulls, the situation is similar: 10.4% in the control group and 5.9% in the experimental group (Table 1).

***Table 1**. Influence of automated feeding on physiological parameters and disease incidence in cattle*

| Metric | Control cows (traditional feeding) | Experimental cows (automated feeding) | Control bulls (traditional feeding) | Experimental bulls (automated feeding) | Reduction (%) |
|---|---|---|---|---|---|
| Body temperature, °C | 38.9 ± 0.3 | 38.6 ± 0.2 | 39.0 ± 0.3 | 38.7 ± 0.2 | -0.8% |
| Heart rate, bpm | 66 ± 4 | 60 ± 3 | 70 ± 5 | 63 ± 3 | -9.0% |
| Respiratory rate, breaths/min | 28 ± 3 | 24 ± 2 | 32 ± 3 | 27 ± 2 | -14.3% |
| Blood glucose concentration mmol/l | 3.9 ± 0.4 | 3.5 ± 0.3 | 4.2 ± 0.5 | 3.8 ± 0.4 | -10.3% |
| Incidence of gastrointestinal diseases, % | 22.5% | 9.5% | 25.8% | 11.3 % | -57.9% |
| Hoof diseases, % | 18.2% | 7.8% | 20.1% | 9.0% | -58.2% |
| Metabolic disorders, % | 13.2% | 6.7% | 10.4% | 5.9% | -49.2% |

***Source:** compiled by the authors*

Thus, automated feeding systems significantly improve animal health, and reduce stress levels and the incidence of diseases, which increases milk and meat production.

**Assessment of stress levels and behavioural responses of livestock during traditional and automated feeding.** One of the key parameters for assessing stress is the level of cortisol, which was significantly reduced in animals of the experimental group. The average level of cortisol in cows of the control group was 5.1 ± 0.5 nmol/l, while in cows of the experimental group – 3.6 ± 0.4 nmol/l, which indicates a 29.4% reduction in stress load. A similar trend was observed in bulls, where the level of cortisol decreased from 5.4 ± 0.5 nmol/l in the control group to 4.0 ± 0.4 nmol/l in the experimental group, which is a decrease of 25.9%.

The assessment of livestock behavioural reactions demonstrated a decrease in the frequency of aggressive interactions between animals when using automated feeding systems. In the control group, 23% of cows and 27% of bulls had conflicts overfeeding, which manifested themselves in the form of pushing, displacement of rivals from feeders and minor fights. In the experimental group, these indicators decreased significantly the frequency of aggressive behaviour in cows decreased to 8%, and in bulls to 11%, which is almost three times lower than in the control group. Animals of the experimental group showed longer feed consumption time, which is an important indicator of the calm state of animals. In the control group, the average feed intake time was 25 ± 4 minutes in cows and 22 ± 3 minutes in bulls, while in the experimental group, this figure increased to 30 ± 3 minutes in cows and 28 ± 2 minutes in bulls. Increasing the time of feed consumption improved digestion and reduced the risk of acidosis and other gastrointestinal diseases.

A significant increase in the total time spent by animals at rest was also recorded. Cows in the control group were observed lying down for an average of 10.8 ± 1.3 hours per day, while in the experimental group, this figure was 12.5 ± 1.2 hours, which is 15.7% more. In bulls, similar indicators were 9.9 ± 1.2 hours in the control group and 11.4 ± 1.1 hours in the experimental group. A longer rest period restores the body, improves metabolic processes and optimises body weight gain. Another important indicator was a decrease in the frequency of social conflicts related to feeding. In the control group, 21% of cows and 25% of bulls recorded episodes of active displacement of rivals from feeders, while in the experimental group, this figure dropped to 6% in cows and 9% in bulls, indicating a significant improvement in social stability in the herd. The results of the study also demonstrated a decrease in the time that animals spent standing without eating feed, which

can be a marker of discomfort or anxiety. In the control group, this figure was 35% in cows and 38% in bulls, while in the experimental group, it decreased to 22% in cows and 24% in bulls (Table 2).

***Table 2**. Assessment of stress level and behavioural reactions of livestock during traditional and automated feeding*

| Metric | Control cows (traditional feeding) | Experimental cows (automated feeding) | Control bulls (traditional feeding) | Experimental bulls (automated feeding) | Reduction (%) |
|---|---|---|---|---|---|
| Cortisol level, nmol/l | 5.1 ± 0.5 | 3.6 ± 0.4 | 5.4 ± 0.5 | 4.0 ± 0.4 | -29.4% |
| Frequency of aggressive behaviour, % | 23% | 8% | 27% | 11% | -65.2% |
| Average feed consumption time, min | 25 ± 4 | 30 ± 3 | 22 ± 3 | 28 ± 2 | +20% |
| Rest time, h/day | 10.8 ± 1.3 | 12.5 ± 1.2 | 9.9 ± 1.2 | 11.4 ± 1.1 | +15.7% |
| Number of social conflicts per day (blows, oustings), % | 21% | 6% | 25% | 9% | -71.4% |
| Frequency of standing without feed intake, % | 35% | 22% | 38% | 24% | -36.5% |

***Source:** compiled by the authors*

Thus, automated feeding systems significantly reduce animal stress levels by distributing feed evenly, reducing competition and improving overall health. This has a direct impact on the productivity of dairy cows and beef bulls, contributing to higher milk yields, better weight gain and overall animal welfare. Automation of the feeding process improves livestock conditions and optimises the production performance of Ukrainian farms.

**Comparison of cattle productivity with traditional and automated feeding.** The average daily weight gain of bulls was significantly higher in the experimental group compared to control animals. The bulls fed by the traditional method had an average weight gain of 1.12 ± 0.07 kg per day, while in the experimental group, this figure reached 1.38 ± 0.05 kg per day. This indicated an increase in weight gain by 23.2%, which was the result of a stable feed intake, its uniform distribution throughout the day and the absence of competition between animals.

A similar situation was observed in beef cows. In the control group, the average daily weight gain was 0.92 ± 0.06 kg, while in cows fed through automated systems, this figure increased to 1.17 ± 0.04 kg. The weight gain in this group increased by 27.2%, which was due to better feed digestibility, improved metabolism and the absence of stress factors associated with uneven feeding. The milk yield of dairy cows also demonstrated a significant increase when using automated systems. The average daily milk yield in the control group was 22.5 ± 1.2 litres, while in the experimental group, it increased to 26.8 ± 1.1 litres. This indicated a 19.1% increase in productivity. The main reasons for this increase were stable feed intake, improved digestive efficiency and reduced stress levels (Lutsenko & Popkov, 2024).

Another important indicator that influenced animal performance was the feed digestibility rate. This parameter determined the efficiency of the use of nutrients supplied by the feed. In the control group, the feed digestibility rate was 64%, while in the experimental group, it increased to 72%, indicating a more efficient use of nutrients. The higher feed digestibility rate reduced feed losses and also reduced the burden on the animals' digestive system (Verzhykhovsky & Nedosekov, 2024). An increase in the average duration of feed consumption was also recorded. In animals of the control group, this figure was 25 ± 4 minutes, which indicated rapid feed intake and possible risks of incomplete assimilation. In animals of the experimental group, the average feed intake time increased to 30 ± 3 minutes, which enusred even digestion of food and prevention of acidosis, rumen disorders and other digestive disorders (Fig. 1).

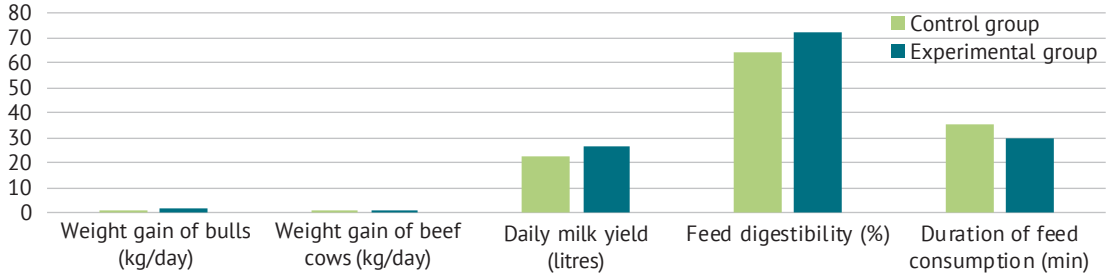


***Figure 1**. Comparison of cattle productivity with traditional and automated feeding*
***Source:** compiled by the authors*

Thus, the data obtained confirmed that the introduction of automated feeding systems is an important factor in improving the efficiency of cattle breeding. They increased average daily weight gain, higher milk yields, improved nutrient absorption and reduced stress in animals. The air temperature in the feeding area was critical for the health of the cattle, as overheating or hypothermia could hurt the productivity and body condition of the animals. In the control group, where the traditional feeding system was used, the average temperature was 18.5°C, which could cause discomfort for the cattle, especially in high-density conditions. In the experimental group, where automated feeding systems were used, the average temperature in the feeding area dropped to 16.8°C, which contributed to a more comfortable environment and prevented overheating of the animals.

**The impact of automation on the microclimate in the feeding area.** Humidity levels in the feeding area also differed between groups. In the control group, the air humidity was 72%, which exceeded the optimum levels for comfortable cattle keeping and contributed to the development of pathogenic microflora. In the experimental group, the humidity level dropped to 65%, which corresponded to the recommended parameters for cattle. This improvement was attributed to more uniform feed consumption and less spilt water due to the automated feed mixtures. One of the key indicators of microclimate quality was the level of ammonia in the air, which was formed as a result of the decomposition of organic matter and could adversely affect the respiratory system of animals (Montayeva *et al.*, 2023). In the control group, the ammonia concentration reached 15 ppm, which posed a risk of mucosal irritation and respiratory diseases. In the experimental group, this figure decreased to 8 ppm, indicating a significant improvement in the air environment. This was caused by a reduction in feed residues and more efficient air circulation around the automated feeders.

Feeder cleanliness was one of the most important factors affecting animal health and performance (Yakubchak *et al.*, 2018). In the control group, the average cleanliness level of the feeders was 68%, indicating frequent accumulation of feed residues and contamination caused by mechanical food distribution. In the experimental group, the cleanliness of the feeders increased to 89%, which significantly reduced the risk of microbial contamination of feed and the development of pathogenic bacteria. The quality of the feed also improved with the automated feeder. In the control group, the average feed score was 75%, indicating a certain decrease in quality due to the possibility of oxidation of feed residues and contamination with dust or litter. In the experimental group, this figure increased to 92%, which ensured better nutrient absorption and reduced the risk of foodborne diseases (Fig. 2).

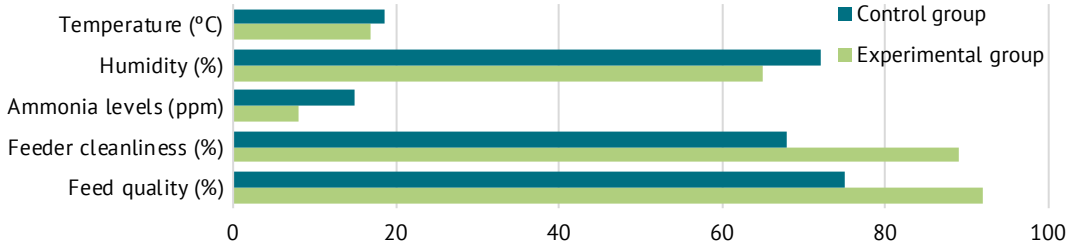


***Figure 2**. The impact of automation on the microclimate in the feeding area*
***Source:** compiled by the authors*

Thus, the results of the study confirmed that the automation of the feeding process not only increased the efficiency of feed use but also significantly improved the microclimate parameters in the feeding area. This made automated feeding systems an appropriate method for ensuring comfortable conditions for cattle in modern farms.

**Comparison of cattle performance in Ukraine and Europe.** Physiological parameters of cattle differed significantly between Ukrainian and European farms. The average body temperature of cattle in Ukraine was 38.9°C, while on farms in Germany, the Netherlands and Denmark this figure was lower and was within 38.6°C, indicating more comfortable conditions for the animals. The heart rate of cows on Ukrainian farms was 66 ± 4 beats/min, while in Germany, the Netherlands and Denmark this figure was lower – 62 ± 3 beats/min, indicating a lower level of physiological stress. Similarly, the respiratory rate was higher on Ukrainian farms (28 breaths/min versus 25 breaths/min in the above European countries), which also indicated the influence of stress factors.

The incidence of nutrition-related diseases in Ukraine was significantly higher than in Germany, the Netherlands and Denmark. Gastrointestinal disorders were recorded in 22.5% of animals in Ukraine, while in European countries this figure was 12.3%. Hoof diseases, which are often the result of an unbalanced diet and unsatisfactory housing conditions, occurred in 18.2% of cases on control Ukrainian farms, while on farms in Germany, the Netherlands and Denmark, the frequency was much lower at 9.1%. Metabolic

disorders (ketosis, acidosis) were also more common in Ukraine (13.2%), while on European farms this figure was only 6.4%, indicating better feed quality and more effective nutrition management. The stress levels of the animals also differed significantly. In Ukraine, cattle blood cortisol levels averaged 5.1 nmol/l, while in Germany, the Netherlands and Denmark, this figure did not exceed 3.8 nmol/l. This was due to more stable housing conditions, lack of competition for feed and the use of automated feeding systems on most European farms. In addition, in Germany, the Netherlands and Denmark, cattle spent more time resting (12.8 hours per day on average, compared to 10.8 hours in Ukraine), which contributed to better recovery and improved productivity.

A comparison of productivity demonstrated a significant gap between Ukrainian and European farms. In dairy farming, the average daily milk yield in Ukraine was 22.5 litres, while in Germany, the Netherlands and Denmark it was 29.4 litres, which is 30.7% higher. This was determined by better livestock genetics, efficient feed management and the use of modern automated technologies. In the beef cattle sector, the average daily weight gain of bulls in Ukraine was 1.12 kg, while on European farms – it was 1.42 kg, indicating more efficient feed intake and higher quality of food additives. Sanitary conditions in the feeding area also varied significantly (Karatieieva *et al.*, 2024). In Ukraine, the level of cleanliness of feeders was estimated at 68%, while in Germany, the Netherlands and Denmark this figure reached 85%, indicating a better organisation of the cleaning and control system. Similarly, the quality of feed in European countries was estimated at 92%, which was significantly higher than in Ukraine (75%). This affects nutrient absorption, disease rates and livestock productivity (Fig. 3).

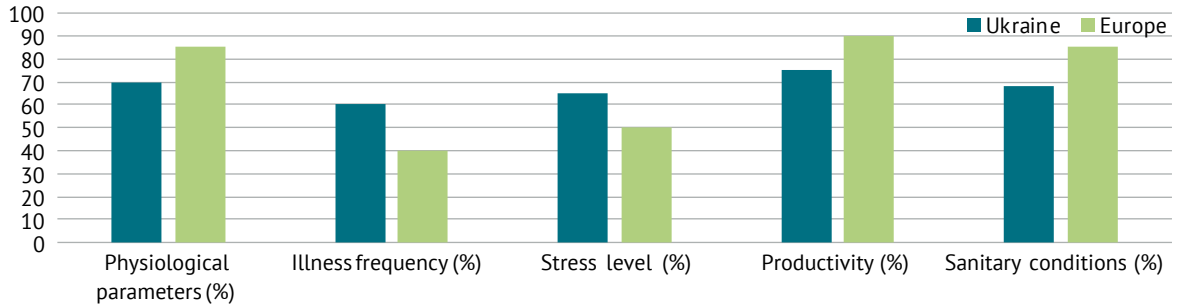


***Figure 3**. Comparison of cattle performance in Ukraine and Europe*
***Source:** compiled by the authors*

Thus, the analysis of indicators between Ukraine and countries such as Germany, the Netherlands and Denmark pointed to significant advantages for European farms. Improved sanitary conditions, efficient feeding strategies, and the wider use of automated systems contributed to lower stress and disease levels in animals, increased productivity, and optimised costs. These findings highlighted the need to implement similar approaches in Ukraine to improve the efficiency of livestock production.

## DISCUSSION

The results of the study confirmed that automated feeding has a positive effect on the physiological state, productivity and stress level of cattle. The study determined that the animals in the experimental group had more stable physiological parameters, a lower level of diseases and increased average daily weight gain. The automated systems ensured an even distribution of feed, which reduced competition among animals and improved nutrient absorption. The data obtained are consistent with the results of European studies in terms of improved milk yields and feed efficiency. A comparison with farms in Germany, the Netherlands and Denmark showed that automated feeding systems contribute to a stable metabolism and increased milk yield, which confirms their effectiveness. An analysis of sanitary conditions showed that automation reduced contamination of feeders and improved the microclimate, which is an important factor for livestock health.

As confirmed by U. Kaur *et al.* (2023) and M.M. Mijwil *et al.* (2023), the use of automated systems in livestock production contributes to increased milk yields and efficient feed use through uniform distribution and minimisation of food losses. These conclusions are fully consistent with the results of this study, which also established an increase in milk yield in dairy cows and weight gain in bulls due to an improved feeding regime. At the same time, the study by U. Kaur *et al.* analysed mainly dairy breeds, while this study also covered the meat sector, which improves the assessment of the benefits of automation in various aspects of animal husbandry. M.M. Mijwil *et al.* conducted a general overview, while the current study provided specific empirical indicators of the impact of automated technologies on animal productivity and health.

As noted by S. Morrone *et al.* (2022) and J. Bae *et al.* (2023), the introduction of Industry 4.0 technologies and autonomous feeding systems improved farm management, ensuring the stability of physiological

parameters and improving the absorption of feed nutrients. These authors also confirmed the reduction of competition for feed due to the automated mode. Their findings are consistent with the results of this study, in particular concerning improved physiological conditions and animal performance. At the same time, this study additionally analysed the sanitary conditions in the feeding area and the microclimate, which were understudied by S. Morrone *et al.* and J. Bae *et al.* As a result, this study provides a more comprehensive analysis of the impact of automation. A. Singh *et al.* (2022) and M. Kraft *et al.* (2022) confirmed that the use of smart technologies in livestock farming can reduce physiological stress and ensure the stability of the feeding regime. The authors emphasised the importance of stable livestock conditions, which also corresponds to the results of this study. However, the study by A. Singh *et al.* did not sufficiently cover the impact of automation on livestock productivity, while M. Kraft *et al.* mainly analysed the management aspects of technology. The present study comprehensively considered the physiological, productive and sanitary aspects of automation, which provided a more complete picture of the impact of modern feeding systems on the conditions of housing, health and productivity of cattle.

As confirmed by A. Kumar *et al.* (2024) and P.A. Vlaicu *et al.* (2024), automation of livestock feeding processes increases the physiological comfort of animals, reducing stress factors and optimising feed management. These studies determined an improvement in cattle productivity due to the precise distribution of feed and the stability of diets, which fully coincides with the results of this study. At the same time, Kumar *et al.* emphasised the role of artificial intelligence technologies in optimising management processes, while P.A. Vlaicu *et al.* addressed welfare and sustainability aspects. This study extended these findings by adding empirical results on the impact of automated systems on the incidence of diseases and sanitary conditions, which the authors of the above works did not consider in detail.

As noted by M.A. Hayden *et al.* (2022) and C. Cheng *et al.* (2023), the introduction of automation on livestock farms improved worker safety, reduced physical activity and increased the accuracy of feeding operations. M.A. Hayden *et al.* emphasised that automation helps to reduce the number of injuries and improves overall production safety. C. Cheng *et al.* additionally emphasised the technical advantages of robotic systems, such as improved feeding accuracy. The results of this study also confirmed the benefits of automation, but it takes a deeper look at the direct impact of automated systems on animal physiology and the microclimate in the feeding area, which improved the comprehensiveness of the results. At the same time, M.A. Hayden *et al.* and C. Cheng *et al.* did not cover the physiological and sanitary aspects, which are discussed in detail in this study.

As emphasised by G. Attard (2023) and R. Sparrow and M. Howard (2021), robotic technologies in agriculture increase the efficiency of feeding management and reduce the impact of the human factor, which ensures the stability of animal conditions. G. Attard indicated that robots improve livestock welfare by reducing competition for feed and stable distribution of rations, which coincides with the results of this study. R. Sparrow and M. Howard additionally emphasises the ethical aspects of robots, such as reducing stress and improving animal welfare. This study also determined a positive impact of automation on physiological parameters, disease incidence, and stress levels. However, G. Attard, R. Sparrow and M. Howard analysed general theoretical aspects, while this study empirically confirmed the specific benefits of automation in the case of cattle in Ukraine.

According to L.F.P. Oliveira *et al.* (2021) and M.A. Alanezi *et al.* (2022)., the use of modern technologies, in particular unmanned aerial vehicles (UAVs) and robotic systems in livestock production, optimising the control and feeding processes, reducing resource consumption and improving the accuracy of operations. M.A. Alanezi *et al.* highlighted the remote monitoring of livestock, while L.F.P. Oliveira *et al.* emphasised the importance of introducing robots for precise feed distribution. These conclusions correlate with the study, but this study analyses in depth the impact of automation on physiological parameters and stress levels in animals, which is lacking in the above-mentioned authors. Thus, this study complements the results of these authors by revealing a wider range of the impact of automation on livestock health.

According to C.R. Eastwood *et al.* (2022) and T. Martin *et al.* (2022), the use of robotic technologies in dairy farming improved working conditions, livestock welfare and farm productivity through a sound and responsible approach to implementation. C.R. Eastwood *et al.* emphasised the importance of systematic design of robots for dairy farms, while T. Martin *et al.* analysed changes in farm labour organisations under the influence of robotics. Compared to these studies, the present study addresses the physiological and sanitary aspects of automated feeding, including disease rates and feed quality, which were not analysed in detail by the above-mentioned authors. As a result, this study has the advantage of being more comprehensive and specific in its analysis of the impact of automation on livestock welfare.

As noted by E.S. Mohamed *et al.* (2021) and K.B. Yılmaz (2024), the use of smart technologies and automated systems in animal husbandry contributes to sustainable development, efficient resource management and improved physiological performance of animals. E.S. Mohamed *et al.* analysed the general benefits of implementing smart technologies to reduce stress, and K.B. Yılmaz emphasised the importance of integrated automated herd management systems. Compared to the results of these authors, the present study is more

empirical in nature and includes an analysis of specific changes in physiological parameters, morbidity, microclimate and animal productivity. As a result, the results are more practically oriented and improve the accuracy of assessment of the benefits of automation on farms in Ukraine. Automated feeding improves the physiological state of livestock, reduces stress and increases productivity, which is confirmed by various studies. Contrary to other studies, this study comprehensively analysed the physiological, productive and sanitary aspects of automation in Ukrainian livestock production.

## CONCLUSIONS

The study determined that the use of automated cattle feeding systems improved physiological parameters, animal productivity and the sanitary condition of the feeding area. The study included 200 dairy cows and 150 beef bulls, which were divided into a control group (traditional feeding) and an experimental group (automated feeding). The analysis of changes in the physiological state of the animals included an assessment of body temperature, heart rate and respiration rate, stress level and morbidity. Animal productivity was also studied in terms of average daily weight gain and milk yield, as well as changes in microclimatic conditions in the feeding area.

The study demonstrated that the body temperature of animals fed through automated systems was 0.3°C lower compared to traditional feeding, indicating a stable physiological state and less stress on the body. The heart rate in the experimental group decreased by 9% and the respiratory rate – by 14.3%, which confirmed the reduction of stress on the animals. The incidence of gastrointestinal disorders was more than halved, and cases of metabolic disorders decreased by 49.2%. Animal productivity under automated feeding has increased significantly: the average daily weight gain of bulls has increased by 23.2%, and the milk yield of dairy cows – by 19.1%. These results confirmed that stable feed distribution, optimised ration composition and the absence of competition for food contribute to better nutrient absorption and overall productivity. The study also demonstrated improved sanitary conditions in the feeding area. Ammonia levels were reduced by 22%, which had a positive impact on the general condition of the cattle and reduced the risk of respiratory diseases. Air humidity has stabilised at 65-70%, and the cleanliness of the feeders has improved by 17%, which has also reduced the risk of spreading infectious diseases. Comparison with European farms demonstrated that feeding automation can reduce the gap between Ukrainian farms in terms of key indicators of animal productivity and health. It was found that the use of modern technologies significantly improves livestock conditions, reducing stress and morbidity. A limitation of the study was that the experiment was conducted on a single farm, which may limit the generalisability of the results for different climatic zones and farm types. Further research should cover the long-term impact of automated feeding systems on livestock reproductive performance and their economic efficiency in different regions.

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## CONFLICT OF INTEREST

None.

## REFERENCES

[1] Alanezi, M.A., Shahriar, M.S., Hasan, M.B., Ahmed, S., Sha'aban, Y.A., & Bouchekara, H.R.E.H. (2022). Livestock management with unmanned aerial vehicles: A review. *IEEE Access,* 10, 45001-45028. doi: 10.1109/ACCESS.2022.3168295.

[2] Attard, G. (2023). Robots in livestock management. In Q. Zhang (Ed.), *Encyclopedia of smart agriculture technologies* (pp. 1-12). Cham: Springer. doi: 10.1007/978-3-030-89123-7_245-1.

[3] Bae, J., Park, S., Jeon, K., & Choi, J.Y. (2023). Autonomous system of TMR (Total Mixed Ration) feed feeding robot for smart cattle farm. *International Journal of Precision Engineering and Manufacturing,* 24, 423-433. doi: 10.1007/s12541-022-00742-y.

[4] Chebotar, D. (2024). Application of artificial intelligence to optimize processes on farms. In *IX all-Ukrainian scientific and practical conference with international participation "Modern information technologies in education and science"* (pp. 488-494). Zhytomyr: Ivan Franko Zhytomyr State University.

[5] Cheng, C., Fu, J., Su, H., & Ren, L. (2023). Recent advancements in agriculture robots: Benefits and challenges. *Machines*, 11(1), article number 48. doi: 10.3390/machines11010048.

[6] Dayoub, M., Shnaigat, S., Tarawneh, R., Al-Yacoub, A., Al-Barakeh, F., & Al-Najjar, K. (2024). Enhancing animal production through smart agriculture: Possibilities, hurdles, resolutions, and advantages. *Ruminants*, 4(1), 22-46. doi: 10.3390/ruminants4010003.

[7] Dilaver, H., & Dilaver, K.F. (2024). Robotics systems and artificial intelligence applications in livestock farming. *Journal of Animal Science and Economics*, 3(2), 63-72. doi: 10.5281/zenodo.12518170.

[8] Eastwood, C.R., Rue, B.D., Edwards, J.P., & Jago, J. (2022). Responsible robotics design – a systems approach to developing design guides for robotics in pasture-grazed dairy farming. *Frontiers in Robotics and AI,* 9, article number 914850. doi: 10.3389/frobt.2022.914850.

[9] European convention for the protection of vertebrate animals used for experimental and other scientific purposes. (1986). Retrieved from https://rm.coe.int/168007a67b.
[10] García, R., Aguilar, J., Toro, M., Pérez, N., Pinto, A., & Rodríguez, P. (2023). Autonomic computing in a beef-production process for Precision Livestock Farming. *Journal of Industrial Information Integration,* 31, article number 100425. doi: 10.1016/j.jii.2022.100425.
[11] Hayden, M.A., Barim, M.S., Weaver, D.L., Elliott, K.C., Flynn, M.A., & Lincoln, J.M. (2022). Occupational safety and health with technological developments in livestock farms: A literature review. *International Journal of Environmental Research and Public Health*, 19(24), article number 16440. doi: 10.3390/ijerph192416440.
[12] Karatieieva, O., Posukhin, V., & Borusiewicz, A. (2024). Sanitary and hygienic assessment of the welfare of Ukrainian Black-and-White cattle breed. *Ukrainian Black Sea Region Agrarian Science*, 28(3), 32-40. doi: 10.56407/bs.agrarian/2.2024.32.
[13] Kaur, U., *et al.* (2023). Invited review: Integration of technologies and systems for precision animal agriculture – a case study on precision dairy farming. *Journal of Animal Science,* 101, article number skad206. doi: 10.1093/jas/skad206.
[14] Kraft, M., Bernhardt, H., Brunsch, R., Büscher, W., Colangelo, E., Graf, H., Marquering, J., Tapken, H., Toppel, K., Westerkamp, C., & Ziron, M. (2022). Can livestock farming benefit from industry 4.0 technology? Evidence from recent study. *Applied Sciences,* 12(24), article number 12844. doi: 10.3390/app122412844.
[15] Kumar, A., Karn, N., Sharma, H. (2024). IoT, AI, and robotics applications in the agriculture sector. In S. Satapathy & K. Muduli (Eds.), *Advanced computational methods for agri-business sustainability* (pp. 243-272). Hershey: IGI Global. doi: 10.4018/979-8-3693-3583-3.ch014.
[16] Lub, P., Kovalyshyn, O., Chukhrai, L., Stanko, V., & Zaplatynskyi, N. (2024). Utilization of intelligent information technologies for resources management in agricultural enterprises. *Bulletin of Lviv National Environmental University. Series Agroengineering Research,* 28, 173-181. doi: 10.31734/agroengineering2024.28.173.
[17] Lutsenko, M., & Popkov, V. (2024). Justification of the basic parameters of a dairy farm for 500 cows with robotic milking systems. *Scientific Reports of the National University of Life and Environmental Sciences of Ukraine*, 20(1). doi: 10.31548/dopovidi.1(107).2024.014.
[18] Martin, T., Gasselin, P., Hostiou, N., Feron, G., Laurens, L., Purseigle, F., & Ollivier, G. (2022). Robots and transformations of work in farm: A systematic review of the literature and a research agenda. *Agronomy for Sustainable Development,* 42, article number 66. doi: 10.1007/s13593-022-00796-2.
[19] Melak, A., Aseged, T., & Shitaw, T. (2024). The influence of artificial intelligence technology on the management of livestock farms. *International Journal of Distributed Sensor Networks*, 2024(1), article number 8929748. doi: 10.1155/2024/8929748.
[20] Micle, D.E., Deiac, F., Olar, A., Drența, R.F., Florean, C., Coman, I.G., & Arion, F.H. (2021). Research on innovative business plan. Smart cattle farming using artificial intelligent robotic process automation. *Agriculture,* 11(5), article number 430. doi: 10.3390/agriculture11050430.
[21] Mijwil, M.M., Adelaja, O., Badr, A., Ali, G., Buruga, B.A., & Pudasaini, P. (2023). Innovative livestock: A survey of artificial intelligence techniques in livestock farming management. *Wasit Journal of Computer and Mathematics Science,* 2(4), 99-106. doi: 10.31185/wjcms.206.
[22] Misiuk, M., & Zakhodym, M. (2023). Digitization as a tool for revitalizing the livestock industry. *Ekonomika APK*, 30(4), 10-24. doi: 10.32317/2221-1055.202304010.
[23] Mohamed, E.S., Belal, A., Abd-Elmabod, S.K., El-Shirbeny, M.A., Gad, A., & Zahran, M.B. (2021). Smart farming for improving agricultural management. *Egyptian Journal of Remote Sensing and Space Science,* 24(3), 971-981. doi: 10.1016/j.ejrs.2021.08.007.
[24] Montayeva, N.S., Montayev, S.A., & Montayeva, A.S. (2023). Studies of Montmorillonitic (Bentonite) clay of Western Kazakhstan as a therapeutic mineral feed additive for animals and poultry. *Agricultural Research*, 12, 226-231. doi: 10.1007/s40003-022-00634-7.
[25] Monteiro, A., Santos, S., & Gonçalves, P. (2021). Precision agriculture for crop and livestock farming – brief review. *Animals,* 11(8), article number 2345. doi: 10.3390/ani11082345.
[26] Morrone, S., Dimauro, C., Gambella, F., & Cappai, M.G. (2022). Industry 4.0 and precision livestock farming (PLF): An up to date overview across animal productions. *Sensors*, 22(12), article number 4319. doi: 10.3390/s22124319.
[27] Oliveira, L.F.P., Moreira, A.P., & Silva, M.F. (2021). Advances in agriculture robotics: A state-of-the-art review and challenges ahead. *Robotics*, 10(2), article number 52. doi: 10.3390/robotics10020052.
[28] Romano, E., Brambilla, M., Cutini, M., Giovinazzo, S., Lazzari, A., Calcante, A., Tangorra, F. M., Rossi, P., Motta, A., Bisaglia, C., & Bragaglio, A. (2023). Increased cattle feeding precision from automatic feeding systems: Considerations on technology spread and farm level perceived advantages in Italy. *Animals*, 13(21), article number 3382. doi: 10.3390/ani13213382.

[29] Singh, A., Jadoun, Y.S., Brar, P.S., & Kour, G. (2022). Smart technologies in livestock farming. In S. Sehgal, B. Singh & V. Sharma (Eds.), *Smart and sustainable food technologies* (pp. 25-57). Singapore: Springer. doi: 10.1007/978-981-19-1746-2_2.
[30] Solona, O., Skoromna, O, & Ohorodnichuk, H. (2023). Application of digital technologies in the field of animal husbandry. *Engineering Energy Transport Aic,* 4(123), 43-50. doi: 10.37128/2520-6168-2023-4-5.
[31] Sparrow, R., & Howard, M. (2021). Robots in agriculture: Prospects, impacts, ethics, and policy. *Precision Agriculture*, 22, 818-833. doi: 10.1007/s11119-020-09757-9.
[32] Tzanidakis, C., Tzamaloukas, O., Simitzis, P., & Panagakis, P. (2023). Precision livestock farming applications (PLF) for grazing animals. *Agriculture,* 13(2), article number 288. doi: 10.3390/agriculture13020288.
[33] Uzedhe, G.O., Akinloye, B.O., & Febaide, I.C. (2023). Development of an animal farm robotic feeding system. *Tropical Journal of Science and Technology,* 4(1), 14-22. doi: 10.47524/tjst.v4i1.15.
[34] Verzhykhovsky, O., & Nedosekov, V. (2024). Key aspects of biosafety in modern animal husbandry. *Ukrainian Journal of Veterinary Sciences*, 15(3), 41-54. doi: 10.31548/veterinary3.2024.41.
[35] Vlaicu, P.A., Gras, M.A., Untea, A.E., Lefter, N.A., & Rotar, M.C. (2024). Advancing livestock technology: Intelligent systemization for enhanced productivity, welfare, and sustainability. *AgriEngineering,* 6(2), 1479-1496. doi: 10.3390/agriengineering6020084.
[36] Yakubchak, O.M., Laposha, O.A., Midyk, S.V., Taran, T.V., & Zabarna, I.V. (2018). Assessment of the conformity of the methods for aflatoxin B1 and deoxynivalenol determination in grain and feeds by method of high-performance liquid chromatography. *Methods and Objects of Chemical Analysis*, 13(3), 121-130. doi: 10.17721/moca.2018.121-130.
[37] Yılmaz, K.B. (2024). Transforming animal husbandry: Leveraging herd management, automation and artificial intelligence for enhanced productivity and sustainability. *Bozok Veterinary Sciences,* 5(1), 23-30. doi: 10.58833/bozokvetsci.1396800.

# Застосування робототехніки для автоматизації годування худоби та управління фермами

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**Анотація**. Метою дослідження було оцінити вплив автоматизованого годування на фізіологічний стан, продуктивність і умови утримання худоби. У дослідженні проаналізовано вплив автоматизованих систем годування на фізіологічні показники, рівень стресу, продуктивність великої рогатої худоби та санітарні умови в зоні годівлі. Експеримент проведено на 200 коровах молочної породи та 150 бичках м'ясної породи, розділених на контрольну (традиційне годування) та експериментальну (автоматизоване годування) групи. Виміряно температуру тіла, частоту серцевих скорочень і дихання, рівень стресу, частоту захворювань, надої молока, середньодобові прирости маси та параметри мікроклімату. Результати показали, що температура тіла в експериментальній групі була нижчою на 0,3 °C (38,6 °C проти 38,9 °C у контрольній), частота серцевих скорочень знизилася на 9 % (60 ± 3 уд./хв проти 66 ± 4 уд./хв), а частота дихальних рухів – на 14,3 % (24 ± 2 вдихи/хв проти 28 ± 3 вдихи/хв). Рівень стресу, оцінений за показниками кортизолу, зменшився на 29,4 % у порівнянні з традиційним годуванням. Захворюваність на шлунково-кишкові розлади знизилася з 22,5 % до 9,5 %, а випадки метаболічних порушень – з 13,2 % до 6,7 %. Надої молока в автоматизованій системі зросли на 19,1 % (26,8 ± 1,1 л/добу проти 22.5 ± 1.2 л/добу), а середньодобові прирости маси у м'ясної худоби збільшилися на 23,2 % (1,38 ± 0,05 кг/добу проти 1,12 ± 0,07 кг/добу). Аналіз мікроклімату в зоні годування показав зниження рівня аміаку на 22 %, покращення вологості до оптимальних 65-70 % і підвищення рівня чистоти годівниць на 17 %. Порівняння з європейськими фермами продемонструвало, що автоматизоване годування дозволяє скоротити відставання українських господарств у продуктивності тварин та санітарних умовах утримання. Отримані висновки підтверджують доцільність впровадження автоматизованих систем годування для зниження рівня захворюваності, підвищення ефективності годівлі та створення комфортніших умов для великої рогатої худоби

**Ключові слова:** фізіологічний стан; санітарні умови; технологічні інновації; ефективність годівлі; кормовий менеджмент