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Using Precision Feeding to Improve Livestock Health and Profit Margins: A Nutritional Risk Management Strategy

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ABSTRACT

The primary economic sector engaged in the breeding, rearing, and production of livestock is referred to as animal husbandry. There are exact standards in place for the production of high-quality feed in animal husbandry. The precision feeding of animals represents a significant component of livestock production, with the potential to exert a considerable influence on overall profitability. Improper animal feeding is a risk that must be managed. Farmers can minimise or eliminate this risk by setting the correct rations for their animals. By properly managing nutritional risk, farmers can improve animal health. This enables the provision of diets that are precisely tailored to the specific daily nutritional requirements of the animals in question. By aggregating data from sensors, a single model can be constructed that can be employed by automated systems to determine daily rations for farm animals. In this document, precision feeding is defined as the practice of adapting diets for individual animals or groups of animals, taking into account their changing nutritional needs over time and individual differences in nutritional requirements. The primary goal of precision feeding is to enhance animal health, ensuring the welfare of the animals, and thereby, their performance, while minimizing the wastage of feed. This document presents a methodology for determining the nutrients required by cows during the dry period. In this manner, the health of the cow will be maintained. Furthermore, if the cows are in good health, the farmer will experience a reduction in costs and an increase in income, given that the breeding of cows and the production of agricultural products are contingent upon the health of the animals.

Keywords: Mathematical Model, Ration, Animal Feed, Animal Production, Sensors, Risk Management

INTRODUCTION

Precision Livestock Farming (PLF)

Precision Livestock Farming (PLF) represents a revolutionary new approach to animal husbandry that has the potential to enhance animal welfare significantly. It is a system that offers many advantages and ensures maximum use of all resources, thus controlling the health of the animals. PLF helps to maximize productivity through the judicious use of feed, water, medication, and supplements. This approach makes real-time supply chain management convenient and easy across the livestock industry. Last but not least, it helps reduce greenhouse gas emissions. It enables better trade in livestock products and enhances rural economic development. In turn, more reliable farm statistics, depending on feedback from different farms, can lead to more successful farms and help make smart business decisions for economic development. [1]

PLF is key to meeting the world's growing demand for quality animal products combined with a responsible attitude to nature in terms of resource consumption and pollution. Smart livestock production is based on the use of information and communication technologies combined with tools that support decision-making and improve the efficiency, productivity, and profitability of farmers' operations. The application of intelligent devices allows the improvement of traditionally used methods and tools by providing detailed information on the environment and the condition of the animals in real-time. Of equal importance is the automation of various tasks or the possibility to carry them out remotely.

The paper focuses on the importance of precision livestock farming, especially in light of growing global food demands and the need to enhance efficiency in animal husbandry. It highlights the economic and environmental

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advantages of precision feeding, which reduces feed waste and optimizes animal health during critical periods. The article introduces advanced technologies like IoT, wearable sensors, and machine learning, emphasizing their role in modernizing traditional farming methods. A key contribution is the focus on precision feeding tailored to cows during critical stages like the dry period and early lactation, using real-time data to improve feed efficiency and profitability. The paper also discusses sensor technology, such as GPS-enabled collars and boluses, which monitor cow health and behavior, helping optimize feed and detect health issues early.

Risk Management

Evolving uncertainties, risks, and crises related to the natural environment, technology, economic and political environment, as well as globalization still pose a challenge to addressing risk management in the agricultural sector in Bulgaria. Risk management is often dependent on the economic activities and internal attitudes of farm managers. The methodological framework of the study includes a theoretical review of risk management in the agricultural sector, identifying sources of uncertainty and risk, the ability of farmers to use different risk management strategies, and the dependence of risk management on farmers' perceptions and government measures taken.

Individual behaviors and actions causing risk can be a variety of: mistakes and ignorance (lack of sufficient knowledge, information, and training); risk-taking strategy (taking a "higher than normal" risk); poor management (poor planning, prevention, recovery), etc., Risk can be internal to the agrifood chain as a hazard from one element to another, and remaining or eliminated within the sector. It can also be external, related to a hazard coming from external factors (natural environment, government policy, international trade) and/or affecting external components (consumers, inhabitants, industries, nature). Finally, risk can be private, where it is borne by individuals, collectives, organisations, industries; it is often public, affecting large groups, communities, consumers, society, future generations.

A risk is significant when there is a high probability that the risk event will occur, and it is associated with high possible negative consequences (losses). The latter can take many forms - destroyed property and health of humans and animals, reduced yield and income, and loss of market position. In a narrow sense, risk management involves individual, collective, and societal action to reduce or eliminate a particular risk and its negative consequences.

Incorrect animal feeding is a risk that must be managed. Farmers can minimise or eliminate this risk by setting the correct rations to feed farm animals. For this, they need to be prepared with knowledge of what nutrients cows need, for example, to be healthier and more productive. By managing this risk, farmers will be able to improve the health of their animals, thus saving on veterinary and medicine costs. In addition, an increase in production will increase income.

The paper outlines the proposed solution to this risk. The model calculates the amount of feed necessary to supply the required nutrients to the animals.

MATERIALS AND METHODS

The Fundamental Principles of Precision Livestock Feeding

PLF has been proposed as an essential tool in the cattle business to increase farm productivity, sustainability, and competitiveness [1, 2]. Using PLF, farmers can get help managing activities like optimizing feeding strategy and animal health and performance monitoring. Precision feeding (PF) of farm animals is one facet of PLF. Because PF and PLF practices share similar core ideas and objectives as well as benefits for animals and the environment, several authors list PF among PLF practices [3, 4, 5, 6]. The goal is to ascertain the ideal feed mixture composition and quantity for the animals, as well as their real-time distribution throughout the day. In doing so, nutrient use is maximized without sacrificing productivity. For instance, precision feeding can result in a 25% reduction in protein intake. Additionally, there may be a 40% decrease in the amount of nitrogen released into the atmosphere. Precision feeding has the potential to boost agricultural profitability by approximately 10% concurrently. Precision livestock feeding and PLF development rely on ongoing data collection and monitoring, data processing and interpretation, and farm operation control and management.

Precision livestock feeding has the power to affect livestock profitability greatly. It allows farmers to provide

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animals with meals that are exactly customized to meet their unique daily nutritional needs.

One benefit of precision feeding is that it allows farm animals to be fed on an individual basis [10, 11]. Diverse feeding techniques, such as varying meal compositions, amounts, or daily regimens, may be necessary for animals depending on their age, health state, and other characteristics.

In this context, "precision feeding" of livestock refers to the technique of giving specific feed to individual animals or

groups of animals while considering the individual variances in nutritional requirements and how those needs change over time. By decreasing feed waste and its negative effects on the environment, the approach aims to maximize animal health and performance. It is described as the accurate measurement of the nutrients included in feed and feed materials, the accurate formulation of diets, and the assessment of the nutritional requirements of each animal or group [13, 14]. Three essential activities must be combined in order to apply precision animal feeding on farms: 1) automated data collecting, 2) data processing, and 3) actions pertaining to the control and management of the system on the farm [15, 16, 17]. Measurements, data processing, and control measures need to be applied to each animal in order to apply precision animal feeding on an individual basis [18].

PLF Technologies and the Role of Data Analytics, Internet of Things (IoT), and Smart Sensors

By using real-time data to optimize and change various elements that eventually increase performance, digital technology and data collection can further improve precision animal nutrition [19]. Measuring animal, feed, and environmental indicators directly and, where practical, continually is necessary for accurate livestock nutrition. These indications include physical condition (e.g., body weight and composition), behavioral and health indicators (e.g., physical activity and animal interactions), and feed intake (e.g., amount consumed and behavior). The potential for animal monitoring in precision livestock feeding (Fig. 1) is considerable, largely due to the rapid development and widespread availability of contemporary devices and sensor technologies, including biosensors, the Internet of Things (IoT), Wearable Internet of Things (W-IoT), and smart terminals.

Figure 1. Animal monitoring in precision livestock.

The Internet of Things aims to connect a large number of standalone devices (sensors and controllers) to a cloud server, a local network, or the Internet. This leads to the development of an automated intelligent system that provides unified and efficient management by utilizing device data. With the aid of portable sensors, the Internet of Things (IoT) is developing into the so-called portable Internet of Things (W-IoT). It offers many benefits, including simple decision-making, fast data analysis, straightforward upkeep, updating and change, and real-time data tracking [20, 21, 22]. Portable sensors attached to the animal, such as a collar, ear tag, or visual tracking, enable individual monitoring of animal status, including health status, nutrition, food intake quality, milk yield, and estrus (Fig. 2) [23, 24]. The collected data is analyzed and provided to farmers through Internet platforms, allowing for timely adjustments to specific parameters and informed decision-making [25, 26].

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Figure 2. Sensors for monitoring animal behavior

Combining real-time sensor data collected from GPS-enabled collars (Fig. 3), machine learning technologies, and cloud-based services will derive much greater value from different operations in different segments of the producer-to-consumer dairy value chain. The main objective of introducing innovative technology and IoT to monitor animal nutrition is to develop a more accurate and tailored approach to determining rations of feed or mineral supplements. In addition, data on feeding patterns in livestock, especially cows, will provide information to detect health problems at an early stage.

Figure 3. GPS-enabled collars

Precision livestock feeding uses various algorithms to make informed decisions. Predictive algorithms predict feed quantity and composition based on growth stage, health status, and production goals. These algorithms use historical data and external factors to predict future needs. Linear regression models, neural networks, and Support Vector Machines classify animals based on feeding patterns or health indicators. Behavioral pattern recognition algorithms analyze behavioral data from sensors to identify health issues or stress. Time-series analysis and anomaly detection analyze feed intake, activity, or rumination changes over time. Using cameras, image and video analysis algorithms monitor feeding behavior, body condition, and animal movement. Convolutional Neural Networks (CNNs) recognize and categorize specific behaviors and detect changes in body condition. Object detection algorithms track individual animals and their interactions with feeders. Decision trees and rule-based systems provide straightforward decision-making rules for feed management. Multivariate analysis optimizes diets and detects health problems by analyzing multiple variables simultaneously. These algorithms reduce the complexity of high-dimensional data, group animals with similar feeding behavior or health markers, and predict the likelihood of an animal developing health issues.

Cloud platforms are essential for aggregating, storing, and analyzing data from multiple sensors in real-time. These sensors include RFID tags, weight scales, environmental sensors, accelerometers, and cameras. Data fusion algorithms combine data from various sources to comprehensively understand each animal's behavior and environment. Preprocessing steps like normalization, smoothing, or filtering ensure consistency across datasets.

Real-time data processing involves edge computing and stream processing frameworks, which minimize data sent

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to the cloud. Data storage and organization in the cloud are divided into structured and unstructured formats, with time-series databases being used for high-frequency data collection and analysis.

Cloud platforms also offer machine learning training through AI models on large datasets. These models can predict feed intake, detect health issues, and make real-time predictions. Data visualization and dashboard management are provided by user-friendly dashboards that provide real-time updates on feeding behavior, health indicators, and environmental conditions. Farmers can view interactive graphs and alerts, and many cloud platforms offer mobile integration for remote monitoring and control.

Prescriptive analytics algorithms, historical data analysis, and Machine Learning as a Service (MLaaS) provide data analytics and decision support. Prescriptive analytics recommends specific actions based on current situations and predictive insights, while historical data analysis helps identify long-term patterns in feed efficiency, animal health, and environmental conditions.

In addition to maintaining optimal animal health with minimal intervention, the analysis of data from diverse sensors to monitor animal nutrition is also intended to conserve resources for environmental reasons. There are multiple avenues for enhancing the efficacy of global water resource utilization and conservation. One such avenue pertains to the utilization of crop by-products such as animal feed and the administration of feed resources in a manner that more accurately aligns with the prevailing needs over time and across geographical regions. Precision feeding represents a highly effective approach to reducing an animal's feed intake while simultaneously achieving maximum individual growth rates. This approach allows for the provision of the optimal quantity and composition of nutrients at the optimal time for each animal.

Feeding, rumination, and resting are the main activities of ruminants. Thanks to their observation, keepers can make better decisions regarding the organization of grazing, the rations of different feedstuffs, or the doses of feed supplements the animals may need. One of the implemented systems for monitoring the feed intake of cows is based on a combination of devices for measuring the amount of feed and proximity sensors worn by each animal. With this system, it is possible to determine the exact amount of food ingested by each animal. Although this system is relatively accurate and efficient, it is only suitable for intensive livestock production. Other types of systems are needed to measure feed intake on extensive livestock farms. [25]

It is challenging to measure feed quality, but by using a bolus (a cylindrical capsule, in this case containing a sensor) that is swallowed by the cow and remains in her stomach, pH can be accurately monitored and feeds adjusted if necessary. Software has also been developed to enable farmers to select the most appropriate rations for their business. Several objectives are considered to be achieved with this precision feeding, including cost reduction and improved animal health. The software allows calendars to be created to feed the animals and check relevant feedstocks.

Since 80-90% of economic losses due to health problems in dairy cows occur in the critical transition period of 2-3 weeks before and up to about 100 days after calving, proper and adequate supplementation during this period is essential to prevent problems caused by expanding the use of total mixed rations or other standardized feeding systems, and would also improve performance. Precise scheduling of supplements given to dairy cows needs to be done using sophisticated machinery, cloud-based services, and data integration coupled with cow identification through electronic ear tags - thus enabling individual rationing of mineral supplements. [26, 27]

The objective of the farmer is to enhance the quality of the product, which can be considered analogous to yield, productivity, production, and reproduction. Additionally, the farmer must analyze the dairy needs. Another important goal is to reduce the occurrence of animal health problems, the number of veterinary interventions and antibiotic or hormone treatments, the improvement of the work-life balance of farmers, and precise indoor and outdoor positioning through Geo-location of sensors. Feed costs account for more than a third of the final consumer price. This share highlights the important role of feed utilization as a factor for competitiveness and its optimization through better genetics and feeding and breeding methods.

The market activities of farms are aimed at maximizing profit and gaining the largest market share. There is a drive to prevent or minimize the likelihood of failure. [28]

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Achieving a high level of protection of human and animal health is one of the main objectives of food legislation as defined in Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002, laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. [29]

The Utilization of Livestock Food Resources

Feeding dairy cows during the transition period. The transition period covers the time between 60 days before and 60 days after calving. The most critical time during this period is 21 days before and 21 days after calving. Proper nutrition and management during the transition period have a crucial impact on dry matter intake (DMI). SBP is a significant factor influencing both milk production and body weight change in early lactation. Higher PSF earlier in lactation reduces the time cows are in negative energy balance. Minimizing the duration and extent of negative energy balance positively impacts reproduction. Proper feeding during the transition period minimizes the risk of metabolic disturbances in early lactation.

Drought Period

Cows must be in good condition at the time of drying off. On a five-point scale (1-very thin; 5-very fat), the ideal score should be 3.50-3.75. Cows with a score below 3.00 and above 4.00 are problematic, as we have virtually no opportunity to change conditions during the dry period. Cows in poor condition have reduced milk production and low energy reserves, which are insufficient for efficient reproduction. Over-conditioned cows have reduced appetite and are prone to ketosis, difficult calving, placental retention, metritis, and ovarian cysts. [30]

The duration of the dry period should be within 45-60 days. A dry period outside these limits is associated with decreased milk production and metabolic problems in early lactation. Feeding two different rations during the dry period is mandatory. During the first 40 days (early dry period) the ration is low energy and low protein. Dry matter intake is 1.8-2.0% of live weight or for a 600 kg cow 11-12 kg, depending on the quality of roughages. Feeding high-grain corn silage should be avoided to reduce total ration energy. In general, concentrated feeds are not included in the ration during this period. If necessary, it is possible to give concentrated feed with a high protein content to reach the required level of crude protein in the ration.

For the next 20 days, the ration is increased in energy - fed about 50% of the grain that will be included in the ration after calving - about 3.0-3.5 kg per day. The composition of the ration during the late dry period should be as close as possible to that of the post-calving ration, especially as regards roughages. The aim is to prepare the rumen microflora for the post-calving ration. [31, 32]

The crude protein content of both dry rations is limited to 12-14% of dry matter (DM), depending on the quality of the protein sources. Deviations in the level of protein nutrition lead to delayed development of the newborn calf or to calves of large size and difficult calving [33]. Cows should have free access to meadow hay throughout the dry period.

This measure keeps the rumen full and prevents it from shrinking under the pressure of the growing calf. Shrinkage of the rumen during dry-off increases the risk of rumen scour and leads to reduced dry matter intake during the first week after calving, which is associated with low performance and metabolic disturbances. In both dry rations, mineral supplements (salt, bicarbonate of soda, etc.) are excluded. Mineral excess leads to a disturbance of the cation-anion balance in the organism and increases the risk of milk fever. To limit the risk of milk fever after calving, the calcium content of the ration should be limited during dry periods. This is usually achieved by giving mineral supplements specialized for dry-aged animals and limiting or even excluding lucerne, which has an increased calcium content. Table 1 shows the nutrients required by cows during dry periods. Fulfilling these requirements ensures cow health and productivity. Table 1 shows the optimum nutrients needed by cows during this period.

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Table1. Necessary nutrients

Forage raw materials	**Early Dry period**		**Late dry period**	
	kg/day		**kg/day**	
Haylage, 40% DM	15.00		5.00	
Corn silage, 33% DM	3.00		14.00	
Straw	3.20		1.10	
Maize	0		1.10	
Wheat	0		1.00	
Nutritional Composition	**By Norm**	**In the ration**	**By Norm**	**In the ration**
Dry matter	12.00	12.20	12.00	Min. 12.00
Protein	128.00	Min. 120.00	142.00	Min. 130.00
Protein Digestible In The Gut	55.00	55.00	75.00	Min. 75.00
Energy per kg/ DM	750.00	750.00-800.00	893.00	875.00-925.00
Calcium, g/kg DM	3.70	Min. 2.00	4.40	Min. 0
Phosphorus, g/kg DM	4.10	Min. 2.00	4.40	Min. 2.00
Calcium/Phosphorus	0.90	Max. 1.20	1.00	1.200
Nitrium, g/kg DM	*2.50*	*Min. 1.00*	*1.60*	*Min. 1.00*
Magnesium, g/kg DM	*2.00*	*Min. 2.00*	*2.30*	*Min. 2.50*

Mathematical Model of the Problem

To formulate the issue as an optimization problem, it is first necessary to establish its objective. In this case, the objective will be the cost of an animal feed mixture. Based on a suitable amount of the components of s = feed, the limitations take into account the necessary nutrient levels. To make the optimization assessments simpler, the study uses linear relations.

While w_j (BGN/kg) is the particular cost of the ingredients, t_j, is the quantity of the j-th ingredient in the mixture. The quantity of the i-th substance in a unit of the j-th component is denoted by m_{ij} (gram/kg for the ingredient).

Performance model objective:

$$min\ P = \sum_{j=1}^{s} w_j\, t_j, \tag{1}$$

where t_j represents the feed's component quantity. Coefficients c are used to define the costs.

Constraints of the model:

$$\sum_{j=1}^{s} m_{ij} t_j \geq n_j, \tag{2}$$

n_j— minimum amount of components.

$$Z_{min} \leq \sum_{j=1}^{s} t_j \leq Z_{max}, \tag{3}$$

Z_{min}—Minimum total amount of forage;

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Z_{max}—Maximum total amount of forage;

$T_1 < 7$—Maximum amount of hay;

$T_2 < 3$—Maximum amount of silage;

t_1 = kg of hay in the daily mix;

t_2 = kg of silage in the daily mix.

The product, the animal's weight, and a number of other variables affect the overall amount of nutrition consumed daily, monthly, or annually. Dry concentrates, which must be the mainstay of the diet, are typically the basis for the estimate. The goal is to create a ration that meets certain nutritional needs while being cost-effective. The recommended daily intake of nutrients is listed in Table 1, along with the amount of each food item that constitutes one kilogram of that nutrient. Numbers T_1 and T_2, which indicate the maximum amounts of hay and silage, are entered into the Solver function as limitations for the best feasible solution to the problem because it is advised that cows get no more than 10 kg of feed each day.

The linear inequalities that formalize the relative nutrient content of the whole food are the constraints of the problem. A list of nutrients that should be included in animal feed is presented in Table 1. In addition, their relative contents in major feed types are shown in g/kg.

The requirements of the animal determine the amount of hay, maize silage, straw, maize and wheat to be selected. The number of forage meals required by sheep daily is shown in Table 2 from the National Farm Advisory Service.

Applying a "Solver" to Solve the Problem

Risk management in precision livestock feeding requires the application of new feeding concepts and mathematical models that can estimate the nutritional needs of specific animals in real-time. This study presents the solution to this problem, solving an optimization problem using a well-known software package, which is a prerequisite for the practical application of the resulting model. The added value of this research concerns the development of a formal model for animal feed determination. The solution to the problem is illustrated with the Excel package, which is widely popular and used.

The Solver function in Microsoft Excel can optimize certain agricultural economic issues presented in tables. The tables provide a rough, initial solution to the problem, although they may not be optimal. The objective function of a linear problem is determined by the quantity to be optimized, which may involve maximizing feed values or minimizing feed cost per day [50]. The conditions and dependencies of the problem are portrayed as linear relationships in the table. The Solver function menu permits the inclusion of further limitations. The principal parameters of the table are subject to optimization.

As illustrated in Figure 4, the Solver function represents the solution to the problem.

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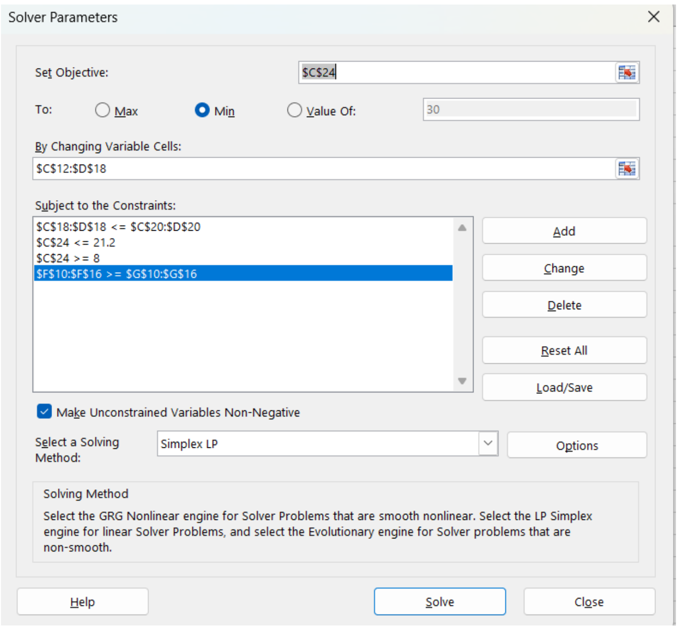

Figure 4. The Solver problem model.

The objective function or the least cost of life is entered into the Set Objective field [34].

The Changing Variable Cells field is filled in with the cells related to the amounts of forage (C18:D18) that need to be changed. The "simplex" approach is used to calculate the ideal feeding cost.

The solution to our problem shows how much feed each cow needs per day to take in the required amounts of nutrients.

These meals provide sufficient dry matter, forage, and digestible protein, together with the appropriate ratios of calcium and phosphorus. Therefore, it is not necessary to add additional minerals to the diet.

In estimating feed costs, the current feeding of the animals is maintained if they are given only hay and silage. The problem solution shows the results in terms of nutrient levels in each choice and the associated costs.

Early Lactation

Formulating rations depends on several priorities. Ensuring that the formulated ration meets the minimum fiber and protein requirements while guaranteeing a high energy density and balancing the carbohydrate and protein fractions for dry matter intake is essential.

The proportion of concentrated feed in the dry matter should be 45% (maximum 50%). With higher concentrate feeding, rumen acidity increases, and the organism falls into subclinical acidosis, associated with low milk production, laminitis, mastitis, and metritis. Another factor in avoiding subclinical acidosis is particle size in the ration. Reduced particle size leads to decreased rumination and salivation and increases the risk of subclinical acidosis. The moisture content of the ration should be 55% (minimum 50%).

A drier ration reduces the cows' appetite. - During the early dry period, the most restricted and therefore economically cheapest ration is recommended. Rely on roughage and mainly on straw. The crude protein content of the dry matter is 16-17 %, depending on the productivity and quality of the protein sources. Particular attention should be paid to possible protein deficiency in the ration associated with low milk production. Cows can compensate for low energy in the ration by using their fat reserves, but protein deficiency cannot be procured in a similar way. [35].

Feeding the cows after calving. Since 80-90% of economic losses due to health problems in dairy cows occur in the critical transition period of 2-3 weeks before and up to about 100 days after calving, proper and adequate

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supplementation during this period is essential to prevent problems caused by expanding the use of total mixed rations or other standardized feeding systems, and would also improve performance. It is important to accurately plan to include supplements given to dairy cows using advanced machinery, cloud-based services and data integration coupled with cow identification - thus enabling the individual determination of mineral supplement rations.

RESULTS

For better nutrition and, therefore, health of the cows during the dry period, it is proposed to install sensors that read the nutrients required by the cow. This sensor takes information and transmits it to a device that is monitored by the farmer. In this way, the farmer will know which nutrients the cow needs at that moment. It is especially important during the dry season to monitor the cows and determine what the ration should be and whether supplementation will be necessary.

The information from the sensors is transmitted to a computer that will calculate the exact amount of feed to be given to the cow. These calculations are made using a mathematical model to determine the required quantities of components, satisfying the requirements for the composition and quantity of the mixture.

Through this model, it will be possible to find the optimal values of the amount of forage, which are represented by means of a mathematical relationship with the performance criteria in the objective function of the model, subject to their set constraints for the problem under consideration. It processes data for a cow farm and finds the distribution of forage, depending on its nutritional values, necessary for the proper rearing of cows during one of the most important periods- the dry season. Based on the results obtained, solutions are proposed to determine what amount of forage (hay and silage) is necessary to feed the cows. [36]

The illustration depicts a cow equipped with sensors that monitor its nutrient requirements. The sensors are linked to a device that displays the levels of nutrients, such as protein and calcium, within the cow's body.

The aim is to formulate a ration that meets the required nutrient intake of the cow, which is so necessary in this period. Cows in poor condition have reduced milk production and low energy reserves, which are insufficient for efficient reproduction. Over-conditioned cows have reduced appetite and are prone to ketosis, difficulty calving, and

other health problems. By feeding correctly and accurately, nutrients will be kept within the norm thanks to information from sensors, and thus, the cow's health will be good.

CONCLUSION

One of the most essential resources in agricultural activities is farm management. It determines the structure of farm life, the allocation of resources, and the way tasks are carried out. It encompasses a range of tactics and approaches to increase and maintain farm productivity and sustainability. To achieve sustainability and productivity on farms, precision livestock production includes precision feeding as a key component. Also, many of the factors that affect the decisions farmers make cannot be predicted with complete accuracy; this is a risk. Farming has become increasingly risky as farmers have become more commercialized. Farmers need to understand risk and have risk management skills to anticipate problems better and reduce consequences. Controlling various parameters significantly reduces the risks and problems faced by farmers. An important part of farm management is to create feed that meets specific nutritional standards and is cost-effective. Using sensors that will provide information about the animal's nutritional needs will calculate the right amount of feed to cover the required nutrients. This will maintain the health of the cows and, therefore, the productivity and income of the farm.

The paper emphasizes the significance of precision livestock farming in meeting global food demands and improving animal husbandry efficiency. It highlights the economic and environmental benefits of precision feeding, which reduces feed waste and optimizes animal health during critical periods. The article introduces advanced technologies like IoT, wearable sensors, and machine learning, modernizing traditional farming methods. It highlights the importance of tailored feeding for cows during critical stages, using real-time data to improve feed efficiency and profitability. Sensor technology, like GPS-enabled collars, also helps monitor cow health.

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