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# Ecological and Technological Evaluation of the Nutrition of Perennial Legumes and their Effectiveness for Animals

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## ABSTRACT

Main task of feed production is to provide farm animals with nutrients. Insufficient or excessive intake of these elements can lead to undesirable consequences. For instance, a deficiency in mineral elements reduces the protective function of the animal's body against various diseases and disrupts the functional activity of organs. Conversely, an excess of any element contributes to the expenditure of a significant amount of energy for its removal and, in some cases, leads to poisoning. Imbalanced animal feeding results in decreased productivity and a deterioration in the quality of products, leading to the production of non-viable offspring and a disruption of reproductive capacity. Our calculations have shown that increasing the energy concentration in the diet from 490 to 600 EFU/kg DM, combined with an increase in feed intake by 4.4 kg, ensures proportional energy consumption based on their productivity difference. In our research, we concluded that it is economically advantageous to use the planned norms of the nutrient requirements for cattle in feed planning.

**Keywords:** fodder production, nutrient content of feeds, productivity, ration, efficiency, mineral compounds, protein.

## INTRODUCTION

Feed production, as intensification based on increased fertilizer application, new high-yielding varieties of fodder crops, chemical plant protection agents, irrigation, modern feed preparation technologies, and the provision of technical equipment for farms, allows for increasing balanced feed production per unit area. However, a significant increase in their production is not always accompanied by a corresponding increase in the volume of livestock products. The main reason for this situation is the underestimation of feeds with qualitative properties [Kovalenko, 2017; Kovalenko and Kovalenko, 2019; Avercheva, 2021; Hryhoriv et al., 2022; Karbivska et al., 2023]. Improving the quality of these basic feeds is one of the important and urgent tasks of feed production, and solving it allows increasing livestock production by 20–25%.

Nutrient content, mineral compounds, and vitamins in the dry matter of green crops is closely related to the cultivation technology and weather conditions. In the case of post-harvest cultivation, it is important to ensure not only high productivity of green mass but also an increased content of dry matter. Accumulation of dry matter depends on biological characteristics, environmental conditions, and the vegetation period when cultivating perennial leguminous plants (soil moisture, air temperatures). Within a single soil–climatic zone, the quality of cultivated fodder can significantly differ depending on the conditions of forming the productivity of fodder crops.

Changes in the dry matter content depending on the air temperature regime, soil moisture, and during the cultivation of sainfoin and alfalfa can be traced based on the data provided in the study.

Analysis of studies dedicated to the mentioned problem in the works of Averchenko [2021], Kovalenko [2021], Korniychuk [2021], Petrichenko [2020, 2021], and others allows us to conclude that approaches to determining the economic efficiency of creating high-productivity agrocenoses of perennial legumes should have a systematic nature. Scientists assert that the chemical composition and quality of green mass of perennial legumes (leguminous) in the conditions of the Right-Bank Forest-Steppe of Ukraine provide an objective understanding of the researched elements of technology and the influence of weather conditions on them. The analysis of feeds was conducted based on the content of dry matter, crude protein, crude fiber, crude fat, non-nitrogen extractive substances (NNES), and crude ash [Petrichenko and Antipova, 2018; Kovalenko and Kovalenko, 2018; Hryhoriv et al., 2023]. Nutritional value of green fodder in feed units was calculated based on the analysis and digestibility coefficients of the determined components.

Effective use of feed for animals is determined by the level of protein supply. An excess of protein in animal diets indicates its irrational use and a disruption of metabolism, while its deficiency significantly increases feed costs per unit of produced output. Determining the optimal protein requirements for animals is a primary factor in achieving high productivity in the livestock industry. Fats also play a significant role in the animal's body. They are essential for the normal functioning of digestive glands, milk formation, and serve as a source of energy.

According to data from Polischuk [2021] and Segeda [2020], a fat content within the range of 3–5% of the dry matter of the feed is sufficient for maintaining the balance to meet the needs of cows. Dietary fiber, along with NDF (neutral detergent fiber), is a complex carbohydrate that is challenging to digest. Elevated fiber content in feeds negatively affects their nutritional value. In the animal's body, fiber is used for fat formation. The quantity of fiber in plants is associated with the vegetation period and their species composition [Kokovikhin et al., 2020; Radchenko et al., 2023].

The recommended content of fiber in the dry matter of the ration for cows with an annual milk yield of 7000 kg should be 20–25%, and for 8000 kg – 15–20%.

Balancing high-nutrient diets by nutrient content can reduce the proportion of concentrates and ensure a substantial milk yield from cows. This can be achieved by obtaining high-quality feed, both roughage and succulent. Fiber content is largely influenced by the botanical composition of crops, the composition of the forage mixture, and the density of the stand. Therefore, increasing the density of plants per unit area leads to a decrease in fiber content.

Ash content characterizes the overall content of all mineral elements present in a plant (phosphorus, sodium, potassium, calcium, etc.). Raw ash content on a dry matter basis ranges from 5 to 11%. The composition of elements in raw ash and their ratios depend on various factors of plant growth and developmental phases. In certain plant organs, ash is distributed unevenly, with stems and leaves containing approximately 1.5–2 times more than seeds and roots [Lavruk, 2017].

Macroelements (phosphorus, calcium, potassium, magnesium, sodium) that enter the animal's body through feed play a crucial role as plastic elements, participating in the structure-building of the organism, especially the skeleton. They are components of cells, tissues, and organs, and activate enzymatic systems. In optimal quantities, ash elements ensure the normal functioning of the organism. Deficiency or excess of these elements in the body can lead to severe diseases and significant reduction in animal productivity.

Phosphorus is one of the most important physiologically active elements, essential for maintaining the normal functioning of the animal's organism. It participates in all energy functions of the body, as well as in the metabolism of fats, proteins, and carbohydrates, and is involved in enzyme synthesis.

The highest amount of phosphorus is found in the bones of animals (almost 87% in adult cows, 63% in young animals). Of the total phosphorus in the body, approximately 10% is found in muscles, and up to 1% in nervous tissue. In the bodies of dairy cows, the phosphorus content can reach 4.1 kg [Yatsiv and Temnenko, 2020]. A potassium deficiency (less than 0.11%) sharply reduces the efficiency of consumed feed, while increasing its content in the ration from 0.66% to 1.08% improves feed palatability and increases milk yield in cows [Petrichenko et al., 2018].

## MATERIAL AND METHODS

The new economic relations, where feeds from crop production and feed production become commodities and are sold to animal husbandry at agreed-upon prices, eliminate impersonal transactions and the transfer of crops without considering their quality. Such relations stimulate production, labor productivity, improve product quality, and reduce costs. The comprehensive application of this system involves justifying the selection of feed crops, reducing losses during conservation and storage of feeds, implementing optimal agronomic practices, and applying commercial and monetary relations between feed production and animal husbandry. It is crucial that the sale at differentiated prices mandates accurate accounting for the quality and quantity of feeds.

The main quality criteria for feeds include the dry matter content, digestibility of energy, digestible protein, energy concentration, and protein–to–energy ratio. Thus, the concept of feed quality is broadened in a new perspective. Some complexity in understanding may arise from the new concept of energy feed units, introduced instead of starch equivalents. Concerning the conversion into oat feed units, it is advisable to use conversion coefficients by Hoffmann [Lavruk, 2017; Provatorov, 2019; Karpenko et al., 2022], which seems quite sufficient.

The production value of a feed is determined by the totality of all its nutritional properties. Properties that can be quantitatively determined play a significant role as indicators.

## RESULTS AND DISCUSSION

During the organization of the production process for growing fodder crops like clover, alfalfa, and sainfoin, it is crucial to consider the chemical composition of the feeds to provide animals with well-balanced nutrition.

In the new system of feed evaluation, all essential indicators for satisfying the nutritional and energy needs of animals and the content of energy and nutrients in feeds have been prepared and formulated for use in the agricultural sector (Table 1).

The energy value and the content of protein with digestible protein amino acids like lysine and methionine + cystine are key indicators that primarily reflect the nutritional value of feed. Therefore, the new feed evaluation system focuses on these two indicators of feed value because meeting the protein and energy needs of animals forms the essential prerequisites for high and sustainable productivity with increased feed efficiency [Long et al., 2018; Hutsol et al., 2021].

In animal husbandry, planned tasks can be successfully accomplished only if feed production is carried out in a scientifically justified manner, taking into account the quantitative and qualitative requirements of respective animal groups. Only with a qualitatively developed comprehensive system for the new evaluation of feeds can successful cooperation between specialized production sectors be achieved. This cooperation would objectively align feed requirements with their supply over a specific period and effectively influence the stability and predictable increase in production. Therefore, the implementation of industrial feed production methods in the assessment of new feeds brings forth new requirements and challenges [Petrichenko and Antipova, 2019; Lü et al., 2019; Guo et al., 2023].

The new feed evaluation should be considered as a unifying link that connects the vital interests and goals of crop production, feed production, and

**Table 1.** Nutritional content of feeds and diets, as well as the energy and nutrient requirements of animals

| Energy and nutrient requirements of animals | Nutritional value of feeds and diets. | Special name | Unit of measurement |
|---|---|---|---|
| Energy requirement | Energy content per 1 kg of dry matter (DM)<br>Digestibility of energy (DE) | Energy concentration (EC) | Energy feed unit (EFU)<br>Digestible energy * 100<br>Gross energy |
| Requirement in: | Content: | | |
| Rumen protein | rumen protein (RP) – at 1 kg DM | Protein concentration (PC) | Protein content unit, g/kg DM |
| Essential amino acids lysine (lys.) methionine + cysteine (met. + cys.) | essential amino acids lysine (lys.) methionine + cysteine (met. + cys.) | | Units of mass |
| Mineral compounds | mineral compounds | | |
| Microelements, vitamins | microelements, vitamins<br>microelements, vitamins<br>Protein-energy ratio (PER) | | RP to EFU |

animal husbandry. Analyzing the feed base using methods and indicators for feed evaluation is an important step in decision-making. Therefore, knowledge of the fundamentals of feed evaluation is equally necessary both when obtaining feeds and during the process of animal feeding. Learning and purposeful application of feed evaluation in production should be regarded as a priority measure for the intensification of feed production and animal husbandry, which are increasingly specializing.

The main scale of energy value is the chain of net energy – fat. Net energy – fat (NEF) indicates the level of energy deposition in the body of adult animals due to feed. As different types of animals respond differently to the energy in feed (especially ruminants and non-ruminants differ in this regard), the energy value of feed should be determined separately for each type of animal.

Practically applying new scientific knowledge to assess the energy of feed in the production sector, it has been found impractical for several reasons to use the basic scale of net energy – fat. Therefore, as a measure of energy value, the energy feed unit has been utilized. The energy feed unit (EFU) for cattle (C), pigs (P), and poultry (Po) is quantitatively expressed as follows:

- 1 EFUc = 2.5 kcal net energy – fat for cattle (NEFc);
- 1 EFUp = 3.5 kcal net energy – fat for pigs (NEFp);
- 1 EFUpo = 3.5 kcal net energy – fat for poultry (NEFpo).

The different values of the energy feed unit for pigs and poultry (3.5 kcal) compared to cattle (2.5 kcal) are well justified. Enzymatic digestion predominates in pigs and poultry, they utilize feed energy more efficiently than sheep and cattle, where substantial energy losses occur during the microbiological transformations of nutrients in the rumen. An average of 40% higher energy utilization has been considered in determining the values of EFU for pigs (EFUp) and chickens (EFUpo). Therefore, the energy feed units for the three types of animals become comparable. In other words, when creating balances and planning, they can be summed up because for feeds that are equally well digested by all three types of animals, the energy nutritive value per unit of feed mass, expressed in EFUc (for cattle), EFUp, and EFUpo, is almost the same.

Deviation from the main trend plays a secondary role in feeding balancing and planning, as typically, it involves not individual feed but the available planned or actual supply of feeds—meaning a large variety of feed types. Hence, differences in the energy value of various feeds for different types of animals are leveled out. To prevent errors in assessing feeds for the balance and planning of rations, energy feed units are selected by animal types [Kovalenko et al., 2021], especially for those that form the basis in the feeding of ruminants, pigs, and poultry.

Primarily, due to the different digestibility of nutrients in individual feeds by cattle, pigs, and poultry, the energy nutritive value expressed in EFUc (for cattle), EFUp, and EFUpo, turns out to be more or less diverse. Therefore, for evaluating energy nutritive value and formulating rations, relevant units specific to each animal type are necessary. Comparing the energy nutritive value of feed for animals of different types allows a more rational use of the feed supply in terms of providing animals with energy (Table 2).

The energy nutritive value of feeds in EFU (Energy Feed Units) is calculated based on the content of digestible nutrients using the following equations: EFUc = 0.68 g RP + 3.01 g RCF + 0.80 g RC; EFUp = 0.73 g RP + 2.44 g RCF + 0.85 g RC; EFUpo = 0.74 g RP + 2.28 g RCF + 0.91 g RC, RP stands for rumen protein. RCF stands for rumen crude fat.

RC stands for rumen carbohydrates (the sum of the rumen digestibility of raw fiber (RF) and rumen digestible non–nitrogenous extractive substances (NNES). The value can be determined by subtracting raw fat and rumen protein from organic matter. When calculating the energy nutritive value for pigs and chickens, it is essential to consider certain characteristics. For feeds rich in sugar, milk, and dairy products, due to the low heat of combustion of sugar (mainly sucrose) and milk fat and the higher heat of combustion of casein, the following adjustments are made to the calculated feed value:

For every 1 gram of sugar, 0.043 EFU (Energy Feed Unit) for poultry (EFUpo) or pigs (EFUp) is added. For every 1 gram of milk fat, 0.286 EFU for poultry (EFUpo) or pigs (EFUp) is added. For every 1 gram of milk protein, an additional 0.286 EFU for for poultry (EFUpo) or pigs (EFUp) is added.

For herbaceous green feeds and the silage obtained from them, as well as dry green feed for pigs and chickens, 10% is subtracted from the determined energy nutritive value. This adjustment is made because these feeds are digested by bacteria

**Table 2.** Energy nutritional value of feeds, important in terms of energy supply, ME (Metabolizable Energy) per 1 kg of dry matter

| Feed | EFUc | EFUp | EFUpo |
|---|---|---|---|
| Perennial leguminous green forage crops | | | |
| Alfalfa, first cutting, pre-budding stage | 555 | 463 | 385 |
| Sainfoin, first cutting, budding stage | 533 | 449 | 362 |
| Cockshead, first cutting, pre-budding stage | | | |
| Dry green forage from perennial leguminous crops | | | |
| Alfalfa, first cutting, pre-budding stage | 516 | 415 | 337 |
| Sainfoin, first cutting, budding stage | 529 | 409 | 319 |
| Cockshead, first cutting, pre-budding stage | | | |

only in the colon of pigs and in the ceca of chickens. Part of the energy is expended on the vital functions of bacteria and the formation of a certain amount of methane, as well as on the increased excretion of energy-rich substances with feces.

The procedure for calculating the energy nutritive value of feeds based on the content of digestible nutrients, including the determination of raw protein, is illustrated in Table 3. To assess the energy nutritive value of feeds depending on different stages of plant development and forms of harvesting and preservation, one can make use of systematically and comprehensively compiled tables. When obtaining tabular values, it is preferable for them to accurately correspond to the specific characteristics of the particular feed. Additional conditions mentioned in the tables, such as harvesting period, fertilizer dosage, conservation efficiency, etc., should be considered [Kovalenko et al., 2020; Tryhuba et al., 2022].

Therefore, the task of calculating and formulating rations is resolved only during feeding. However, there are certain aspects that need to be taken into account in feed preparation to understand the implications of the new energy assessment of feeds.

For poultry and pigs, the energy nutritive value of feeds in diets can be summed up. Therefore, the energy nutritive value of diets for these animal types is determined as the sum of the energy values of the feeds that constitute the animal's diet. This rule holds true for both pigs and chickens.

In ruminants, ruminal digestion precedes interdigestive metabolism. This significantly affects energy metabolism and is a consequence of high energy losses caused by microbial processes in the rumen. The extent of energy losses in the rumen during fermentation varies depending on the diet structure. The digestibility of nutrients in the diet for ruminants allows quantifying the impact of diet structure on energy nutritive value.

The energy feed unit, given its relatively small value, is less practical for planning and balancing purposes in feed production on the farm, especially when dealing with the production of feeds and calculating the energy needs for the entire available livestock. Additionally, when feeding different animal types, such as chickens and lactating cows, the daily energy requirements vary so much that introducing larger energy units is advisable to limit the size of numbers. Using the decimal numbering system, the following units are obtained: 1000 EFU = 1 kEFU (kilo-EFU); 1000 kEFU = 1 MEFU (mega-EFU); 1000 MEFU = 1 GEFU (giga-EFU).

The choice of a specific unit depends on the purpose of its application. In feeding, EFU and kEFU are the most appropriate, while in planning and balancing feed production on the farm,

**Table 3.** Calculation of the energy content of 1 kg of meadow hay for cattle (large ruminants)

| Nutrients | Analysis data, g/kg DM | Digestibility (according to the table), % | Digestible nutrients, g/kg DM | Conversion coefficient | Energy, EFUc |
|---|---|---|---|---|---|
| Crude protein | 94 | 50 | 47 | 0.68 | 32 |
| Crude fat | 21 | 44 | 9 | 3.01 | 27 |
| Crude fiber | 298 | 58 | 173 | 0.80 | 138 |
| BAS | 521 | 62 | 323 | 0.80 | 258 |

kEFU, more commonly MEFU, and sometimes GEFU are used. For example, expressing data on energy yield per hectare in feed production is practical in kEFU or MEFU (Table 4).

The energy nutritive value of feed, calculated per 1 kg of dry matter, is significant both for feed production and animal husbandry. It is independent of the moisture content in the feed and is rightfully referred to as energy concentration [Kovalenko et al., 2021].

The function of energy concentration is essential for comparing and evaluating the energy nutritive value of feeds. Energy nutritive value per 1 kg of feed is not suitable for this purpose due to large differences and fluctuations in moisture content. Only when expressing the energy nutritive value in terms of energy concentration do the differences between certain types of feeds become clear, as well as the influence of factors (soil nutrient content, growth phase, fertilization, harvesting time, conservation, storage) on the same type of feed (Table 5).

The data indicate that, with the same energy nutritive value, 1 kg of feed can differ by more than 20% in energy concentration. The possibility of erroneous assessments is particularly evident in the example of the energy nutritive value of 1 kg of feed harvested in different growth phases. Changes in the energy nutritive value of 1 kg of natural feed and 1 kg of dry matter can occur in different directions throughout the vegetation period [Kovalenko and Halchenko, 2018; Kovalenko et al., 2020].

The increase in the energy nutritive value per 1 kg of feed is explained by the reduction in moisture content, while the decrease in energy concentration is attributed to the formation of structural compounds in plants that impair the digestibility of nutrients. Therefore, feeds should be compared based on energy concentration, as comparing natural feeds does not ensure accurate results [Karpenko et al., 2021; Kovalenko et al., 2021].

For a proper comparison of the energy nutritive value of feeds and other nutritional indicators, it is crucial that comparisons are made on the basis of either the same dry matter content or the same moisture content. In the new feed evaluation system, data on energy nutritive value and the content of all nutrients primarily focus on 1 kg of dry matter in feeds. This ensures a common basis for comparing nutritional value indicators.

Table 6 presents the range of changes in the energy concentration of some feed groups. Energy needs of livestock is not only a matter of the quantity of feed. This is because animals cannot infinitely increase their feed intake. The actual consumption of energy is determined by both the amount of feed consumed and its energy concentration. Both factors are equally important for energy consumption [Korniychuk, 2021; Kovalenko et al., 2020]. Low feed intake can be compensated for by high energy concentration, and vice versa. However, only the combination of high feed intake with high energy concentration creates conditions for satisfying the animal's energy needs under high productivity (Table 7).

Accounting for the impact of energy concentrations on daily energy intake becomes more critical as the demands for animal productivity increase. The higher the productivity, the greater

**Table 4.** Energy yield per 1 hectare in forage production

| Feed | Energy yield per 1 hectare | |
|---|---|---|
| Sainfoin, onset of flowering, first regrowth, first cutting | 1960 KEFUc | 1.96 MEFUc |

**Table 5.** Energy nutritional value of bulky feeds per 1 kg of fresh feed and dry matter

| Forage from perennial leguminous crops | EFUc/kg raw mass | EFUc/kg dry mass |
|---|---|---|
| Sainfoin, silage from freshly cut mass, onset of flowering | 96 | 480 |
| Alfalfa, green mass, first cut, full flowering | 96 | 466 |
| Meadow grass, silage from freshly cut mass, second and third cuts | 98 | 445 |
| Sainfoin, first cutting: | | |
| until budding | 77 | 595 |
| budding | 80 | 553 |
| at the beginning of flowering | 99 | 530 |
| full flowering | 105 | 508 |
| end of flowering | 110 | 488 |

**Table 6.** Range of energy concentration variations in certain groups of feeds

| Groups of feeds | Variations in energy concentration, EFU/kg DM |
|---|---|
| Bulky feeds | |
| Solid phase of non–bedded manure | 250–400 |
| Cereal straw | 350–400 |
| Hay | 400–550 |
| Silage | 425–575 |
| Green forage | 450–625 |
| Dry green forage | 500–600 |

the need for energy that must be met through daily feed consumption. Typically, as productivity increases, feed consumption also increases.

For example, among dairy cows producing 10 and 30 kg of milk per day, the difference in feed consumption can be 5–6 kg of dry matter. This means that for each additional kilogram of milk, the cow consumes 250–300 g of dry matter. However, the ability for additional feed consumption with increasing productivity is insufficient to meet the increased daily energy needs unless the energy concentration in the feed is simultaneously increased.

As milk yield increases, cows may only meet 65–70% of their increased energy needs through increased feed consumption, requiring 30–35% of energy needs to be met by increasing energy concentration in the ration. This is crucial for high animal productivity. The relationship between feed consumption, productivity, energy consumption, and the requirements for energy concentration is shown in Table 8, using the example of a dairy cow. An increase in dry matter intake from 14.9 to 19.3 kg at an energy concentration of 490 EFUc/kg DM is insufficient to meet the additional energy needs with a difference in daily milk yield of 15 kg.

Only with an increase in the energy concentration in the ration from 490 to 600 EDUc/kg DM, combined with an increase in feed consumption by 4.4 kg, can energy consumption be proportionally provided for the difference in productivity.

The calculation of the requirements for roughage and concentrated feeds should be based on feed rations. In a simplified calculation, it is sufficient to calculate the overall need and reasonably divide it into roughage and concentrated feeds.

The nutrient requirements for a cow are determined based on:
- its live weight,
- milk productivity,
- the content of ingredients in the milk (protein, fat),
- stage of lactation,
- mobility and activity of the animal,

The nutrient requirements are further subdivided for:
- maintenance of the cow's life processes,
- cow's productivity (milk, fertility, weight gain, digestion, etc.).

Requirement for feed for dairy cows was calculated for the Educational and Research

**Table 7.** Impact of required feed quantity and energy concentration on energy consumption

| Consumption of DM feed by the animal, kg per day | Energy concentration EFUc/kg DM | Consumption of energy by the animal, EFU per day |
|---|---|---|
| 15 | 500 | 7500 |
| 13.6 | 550 | 7500 |
| 15 | 550 | 8250 |

**Table 8.** Relationship between daily yield, energy requirements, concentration of energy in the diet, and feed consumption by milking cows

| Milk yield, kg, at a milk fat content of 4% | Energy requirements KEFUc per day | Energy concentration EFUc/kg DM | Feed consumption, DM (dry matter) per day, kg. |
|---|---|---|---|
| 5 | 4.4 | 400 | 11.0 |
| 10 | 5.8 | 440 | 13.2 |
| 15 | 7.3 | 490 | 14.9 |
| 20 | 8.7 | 540 | 16.1 |
| 25 | 10.1 | 570 | 17.7 |
| 30 | 11.6 | 600 | 19.3 |
| 35 | 13.0 | 620 | 21.0 |

Institute of the National University of Life and Environmental Sciences of Ukraine, "Agronomic Research Station" [Kovalenko et al., 2018; Kovalenko and Kokovikhin, 2019].

The requirement for energy and crude protein (CP) to sustain life is calculated taking into account the live metabolic mass (LMM):

- At our enterprise, it is equal to: 550 kg $LMM^{0.75}$ = 113.6 kg LMM
- Energy: 113.6 kg LMM × 0.293 × 365 = 12,149 MJ/year
- CP (crude protein): 113.6 kg LMM × 3.9 × 365 = 161.7 kg/year.

The nutritional requirements for milk productivity depend on the qualitative composition of milk and the size of milk yields.

- Energy: requirement for fat – 3.6% fat × 0.38 = 1.368 MJ/kg of milk
  + Requirement for protein – 3.2% protein × 0.21 = 0.672 MJ/kg of milk
  + Constant – 1.05 MJ/kg of milk
  = Total requirement per 1 kg of milk – 3.09 MJ/kg of milk
  × Annual yield – 6,500 kg
  = Requirement per cow per year – 20,085 MJ
- Crude protein: requirement per 1 kg of milk – 3.2% protein × 25 = 80 g/kg of milk
  × Annual yield – 6,500 kg/year
  = Requirement per cow per year – 520 kg
- Calving:
  Energy: 113.6 kg LMM × 0.1 MJ/day × 60 days dry period = 681.6 MJ
  Crude protein: 113.6 kg LMM × 4.2 × 60 days dry period = 28.6 kg

When determining the feed requirements, it is recommended to additionally calculate the livestock feeding ration. For calculating the needs in roughage and concentrated feed, an approximate indicator of the cow's milk productivity from roughage can be used. The necessary amount of concentrated feed is determined based on the cow's productivity not obtained from feeding roughage. The amount of milk obtained per 1 kg of concentrated feed equals 1.8–2.2 kg. By using tables of the nutritional value of feeds, which describe all components of each type of concentrated feed, the overall nutrient content can be calculated. In practice, it is advisable to double-check the calculated norms for the use of concentrated feeds and compare them with actual values [Kovalenko et al., 2018; Szparaga  2019 Petrychenko et al., 2020].

The requirement for roughage is calculated as the difference between the total requirement and the nutrients from concentrated feeds, taking into account losses during feeding. It is recommended to have a 10% reserve of roughage on the farm in case of losses during the feeding process.

According to our calculations, for one lactating cow at the Educational and Research Institute of the National University of Life and Environmental Sciences of Ukraine, "Agronomic Research Station," the requirements are as follows: vEnergy: 36,207 MJ, Crude Protein: 781.1 kg

In the feeding ration for lactating cows, the roughage at the enterprise should constitute 60–70%. However, the actual analysis of rations used in the farm indicates a different distribution, with concentrated feeds making up 60% and bulky feeds 40%. For a ration with 60% roughage, the energy requirement for one lactating cow is 21,724 MJ. Considering the ratio of roughage to succulent feeds as 1:3, and the yields of forage crops used in the ration, the enterprise needs to plan 0.42 hectares for silage and 0.14 hectares for forage crops for hay per lactating cow. Currently, the enterprise has a herd of 160 lactating cows. To meet their nutritional needs, the enterprise would need to allocate 89.6 hectares of land.

## CONCLUSIONS

A balanced feed base for a farm is the foundation for quality dairy farming. Often, when planning the size of areas for fodder crops, farms do not use scientific calculations of animals' energy and crude protein needs, leading to overproduction or underproduction of the main feed. In our research, we have concluded that it is economically efficient to use the standards of nutrient requirements for cattle in feed planning.

The dry matter content in alfalfa, clover, and sainfoin depends on soil moisture and air temperature during cultivation. The efficiency of feed utilization by animals is determined by the level of its provision with digestible protein. Excess protein in animal diets leads to its inefficient utilization and metabolic disturbances, while a deficiency results in significant feed wastage per unit of produced output. Therefore, determining the optimal protein needs of animals remains a crucial factor in achieving high productivity.

When organizing the agricultural production process for growing fodder crops, it is important to consider the chemical composition of feeds from clover, alfalfa, and sainfoin to provide animals with balanced feeds.

The production value of feed is determined by the totality of all its nutritional properties. In the new system of feed evaluation, criteria for meeting the animals' energy and nutrient needs, as well as the content of energy and nutrients in feeds, hold significant importance. The energetic nutritive value and the content of digestible protein or amino acids such as lysine, methionine, and cystine are crucial factors.

However, in practical use, applying the main scale of net energy – fat for the purpose of evaluating the energy content of feed in the production sphere has proven to be impractical for several reasons. Comparing the energy nutritive value of feed for different animal species allows for a much more rational use of the feed resources in terms of providing animals with energy.

The increase in the energy value of 1 kg of feed is explained by reducing the moisture content to the optimal phase during vegetation, while the decrease is due to the formation of subsequent structural compounds in plants that worsen the digestibility of nutrients. Therefore, feeds should be compared based on energy concentration. For a proper comparison of the energy value of feeds and other nutritional indicators, it is important that the comparison is done at the same dry matter content or the same moisture content. Energy needs of animal herds is not just a matter of the quantity of feed; it is also related to the fact that animals cannot infinitely increase their feed consumption. The actual energy intake is determined by the amount of consumed feed and the energy concentration in it. Increasing the energy concentration in the ration from 490 to 600 EFUc/kg DM, combined with an increase in feed consumption by 4.4 kg, ensures energy consumption proportionate to the difference in productivity.

The need for accurate determination of feed value is driven by the transition of agriculture to industrial forms of production. The creation of production units specialized in crop cultivation, feed production, and animal husbandry requires an economic evaluation of the intermediate product – feeds. When establishing prices for feeds, their quality should be taken into account, just as it is done when selling livestock products (milk, meat). For a comprehensive assessment of feed quality, the services of specialized feed analysis laboratories should be utilized.

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