Research of feed protein obtaining technology

G Kokieva 1,2,3, A Cherkashina 1, and T Afanasyeva 1

1 Arctic State Agrotechnological University, Sergelyakhskoe highway, 3 km, building 3, 677007, Yakutsk, Republic of Sakha (Yakutia), Russia
2 North-Eastern Federal University named after M.K. Ammosov, Belinsky st., 58, 677007, Yakutsk, Republic of Sakha (Yakutia), Russia

E-mail: kokievagalia@mail.ru

Abstract. The introduction of high-grade mineral additives in feed allows to get balanced rations for livestock and poultry. It is known that the most effective use of them when feeding in the composition of feed. However, today, in real conditions, farms receive less than 30% of the required amount of chemical feed additives with compound feed. In addition, the outlined tendency towards a decrease in the production of compound feed due to the lack of grain and protein components indicates that the feed industry is not entirely able to solve this problem. Adequate feeding of dairy cows assumes an optimal intake of all essential nutrients in the body, which contributes to good health, normal reproduction and high productivity. A significant reduction in the energy deficit during this period can be achieved by introducing energy-rich feed concentrates, grass cutting and grass flour of high quality, root crops, etc. into the diet. The higher the milk yield of cows, the more energy should be in one kilogram of dry matter of the diet. This article proposes a technology for producing a protein-vitamin feed concentrate for full-value feeding of farm animals. To solve the fodder problem in animal husbandry, it is necessary to more widely use substandard raw materials, organic waste, ensuring their utilization within the framework of waste-free technology.

1. Introduction

One of the factors that reduces the efficiency of livestock production is the imbalance between livestock growth and feed production. Traditional forms of organizing the production of feed do not allow many farms to stably provide the livestock sector with feed, to create safety stocks. This is primarily due to the diversified nature of production, a large range of cultivated crops, a low level of specialization and division of labor in tractor-field and complex brigades. Reforming agriculture, creating a multi-structured economy in the countryside with various forms of ownership of the means of production led to the reorganization of the infrastructure of the agro-industrial complex, in particular, the system of resource provision. In Yakutia, work on improving livestock began in the 30s of the twentieth century. Since 1932, the planned replacement of Yakut cattle with Kholmogorskiy and Simmental breeds by means of cross breeding began. In this regard, it became necessary to carry out selection and breeding work. The breed composition and breed of livestock gradually changed. In the conditions of Yakutia, the process of improving the breed of cattle has its own characteristics and is long-term. Artificial insemination of cows has accelerated the breed transformation process. The Simmental cattle of Yakutia, in comparison with their relatives in the Far East, is more squat and more bony. Simmental has a strong constitution, strong bones and good musculature. The main color of
animals of the Simmental breed is fawn, pale-motley, red-motley and red with a white head are found. [2-4]

2. Research methodology
To replenish the feed deficit, we propose a technology for obtaining feed protein by microbial synthesis in new equipment. Figure 1 shows the equipment for microbial synthesis.[5]

The mixer has a three-tier paddle mixing device, which creates a large turbulence of the liquid flow, and provides mixing of the medium throughout the volume of the apparatus. This design intensifies the mixing process and improves product quality.

![Figure 1. Equipment for microbial synthesis: H - fermenter height; H₀ - liquid level height; h₁ - distance between mixers; h₂ - distance from the bottom mixer to the bottom; dₘ - mixer diameter; D is the diameter of the fermenter; b - the width of the stirrer blade; l - length of the stirrer blade; C is the width of the bumper.](image)

The mixers under study provide complete and uniform distribution of particles throughout the volume of the mixed medium, simplicity, convenience and tightness of the structure. The main task of the study is to identify the effective operating mode of the mixer.[6]

3. Main part
When studying the process of oxygen absorption in a nutrient medium of various viscosities, the equation was adopted to calculate the gas content:

$$\frac{\varphi}{(1-\varphi)^2} = 0,2 \left( \frac{D^2 \rho_a \mu_a}{\sigma} \right)^{0.62} \cdot \frac{1}{\mu_a} \left( \frac{D^3 \rho_a \mu_a}{\mu_a} \right)^{1/2} + \frac{W_r}{(D \sigma)^{0.5}}$$  \hspace{1cm} (1)

where $D$ – apparatus diameter.

At this time, a number of scientists have carried out systematic studies [5-8] and made recommendations for determining $\varphi$ by the following dependence:

$$\varphi = \frac{1}{2 + \left( \frac{0.35}{W_r} \right) \left( \frac{\gamma}{\gamma_0} \right)^{1/3}}$$  \hspace{1cm} (2)

At the moment, during the production of feed protein during the cultivation of microorganisms in the culture liquid, a number of reactions take place in the fermentation liquid with oxygen. A number of authors [7, 11] for reactions with oxygen of liquids, which are widely used in industry, for calculation of $W_r$ the following addiction recommended:

$$H(\rho_h - \rho_r) s = \left[ 1.5 + \lambda_w \frac{H}{d_w} \left( \frac{f_{o_2}}{f_{o_2}} \right)^2 + 2 \cdot \frac{1}{(1-\varphi)^2} + \frac{\lambda_o + H}{(1-\varphi)^{1.75} d_o} \right] \left( \frac{\rho_a W_r^2}{2} \right)$$  \hspace{1cm} (3)
Air films are formed on the gas–liquid interface of an air bubble. They pass through the culture, impede the diffusion of oxygen throughout the fermenter and reduce the resulting resistance.[8-10]

A number of works are devoted to the study of oxygen absorption processes in fermenters [1, 7, 11]. If we consider this case for a poorly soluble gas (oxygen), the values $m_{pc}$ and $K_i$ are large, and the diffusion resistance in the gas phase can be neglected, and the inequality:

$$\frac{1}{K_{l,a}} \gg \frac{1}{K_r m_{pc}}$$

then:

$$k \approx k_{l,a}$$

Based on the equality $k \approx k_{l,a}$ mass transfer equation:

$$\frac{dc}{dy} = k_i \cdot a \left( C_p - C \right) - k_o \cdot x,$$

Left term of the equation:

$$\frac{d^2M}{dV_{dt}} = K_i a \left( C_p - C \right),$$

called the rate of volumetric mass transfer of oxygen, or the rate of oxygen dissolution, for the absorption of air oxygen by the culture liquid is written in the following form:

$$\frac{d^2M}{dV_{dt}} = K_i a \left( C_p - C \right).$$

The stability and efficiency of the applied numerical methods allow for further modification of the calculation technology, including the selection of turbulence models, in order to increase the accuracy of the calculations.[12-13]

At fig. 1 shows a graph of the theoretical and experimental dependence of the productivity of the experimental fermenter on the density of the substrate, taking into account the correction factor $K = 0.85 \cdot Q_{theor}$ with constant variables: specific oxygen consumption ($x_2 = 0.71$, $r = 0.04 \text{ m}^3/\text{m}^3 \text{s}$) and mixer shaft revolutions ($x_1 = 1.36$, $n = 73 \text{ rpm}$).

Criterion $t=3.259<3.707$ (critical) at significance level 0.01, i.e., independent samples belong to the same population at a significance level 0.05 > $p > 0.01$. Significance of the results obtained (F-criterion) $p = 0.805 > 0.75$, i.e., the agreement between theoretical and experimental data is good, $p = 0.805 > 0.75$.

**Figure 2.** Graph of the theoretical and experimental dependence of the productivity of the experimental fermenter on the substrate density, taking into account the correction factor $K = 0.85 \cdot Q_{theor}$ with constant variables: specific oxygen consumption ($x_2 = 0.71$, $r = 0.04 \text{ m}^3/\text{m}^3 \text{s}$) and revolutions agitator shaft ($x_1 = 1.36$, $n = 73 \text{ rpm}$)
The graph in Figure 1 shows how well the theoretical and experimental dependences agree. Analysis of the results of a numerical multivariate experiment made it possible to substantiate the mathematical model of the fermenter productivity in the form:

$$Q = K \cdot 0.248 \cdot 10^{-2} \cdot V^2 \cdot (51.6 + 0.63x_1 + 7.29x_2 + 4.70x_3 - 0.0055x_1^2 - 0.072x_2^2 - 0.045x_3^2 - 0.00078x_1x_3 - 0.00078x_2x_3, \text{ kg/сут})$$

(7)

where

- $K$ – correction factor, $K = 0.85$
- $V_p$ – reactor volume, m$^3$
- $x_2 = r^{0.105}$, where $r$ – specific oxygen consumption, m$^3$/m$^3$·с
- $x_3 = \rho^{0.58}$, $\rho$ – bulk density of the substrate, m$^3$
- $x_1 = n^{0.07}$, $n$ – the number of revolutions of the stirrer shaft, rpm (the values of the variables in the degree are determined using an online calculator on the Internet).[14]

For feeding cows, it is advisable to use complete feed mixtures that contain all the necessary nutrients. As a result, the milk productivity of cows increases by 13-15% and feed costs for products are reduced by 7-10%. Milk productivity of cows is largely determined by the provision of diets with complete protein. The rate of digestible protein per 1 feed unit is 95 g with a daily milk yield of up to 10 kg of milk and gradually rises to 105 - 110 g with a milk yield of 20 kg or more.

Table 1 shows an analysis of the number of cattle.

|                | 2014 | 2015 | 2016 | 2017 | 2018 |
|----------------|------|------|------|------|------|
| Total cattle   | 25   | 22   | 15   | 12   | 11   |
| Milking cows   | 11   | 9    | 6    | 5    | 5    |
| Bulls up to 18 months age | 1 | 1 | 1 | 1 | 1 |
| Cows           | 3    | 1    | 3    | 3    | 3    |
| Calves         | 10   | 10   | 6    | 3    | 2    |

Figure 3. Analysis of the number of cattle.

The business output of calves is 27% (this says that the percentage of pregnancy decreases every year, the insemination of cows is poorly carried out), the average milk yield per lactation is 1124 сn. Milk was produced 4,670 kg, which is 17.6% less than in 2017. In recent years, a decrease in the number of cows has been observed in the peasant farm by 48%, which is quite significant for a small farm. In connection with a decrease in the number of cows, there is a decrease in the gross and marketable output of products by an average of 10% (table 3).
Table 2. Production indicators of the farm

| Indicators                           | Units | 2014   | 2015   | 2016   | 2017   | 2018   |
|-------------------------------------|-------|--------|--------|--------|--------|--------|
| Livestock (cows)                    | Heads | 25     | 22     | 15     | 12     | 11     |
| Milk yield per 1 forage cow         | Kg    | 1158   | 1145   | 1156   | 1134   | 1124   |
| Business outlet of calves           | %     | 40     | 45     | 40     | 25     | 27     |
| Milk produced                       | Kg    | 12738  | 10305  | 6936   | 5670   | 4670   |
| Gross                               | Centner | 148.8 | 103.9  | 81.9   | 60.1   | 50.1   |
| Commodity                           | Centner | 99.3  | 86.4   | 72.0   | 54.3   | 44.3   |

Figure 4. Production indicators of the farm.

Bulky forage should be the basis of winter rations for cows. The optimal amount of hay for dairy cows is 1.7 - 2 kg per 100 kg of live weight of the animal. To provide animals with vitamin R., the amount of hay should be at least 1.6 - 2 kg of their weight. It is recommended to introduce silage into the diet of cows at the rate of 3-4 kg per 100 kg of live weight. Fodder roots - 1.0 - 1.5 kg of milk. Concentrated feed - 250 - 350 g per 1 kg of milk. Our research has shown that the inclusion of the obtained protein in the diets increased milk yield, weight gain, and physiological characteristics. [15]

4. Conclusion
The course of microbial synthesis in devices of different scales in terms of the unit volume of the amount of the product (biomass or metabolic products) will be the same or almost the same in devices of different scales. Adequate feeding of dairy cows assumes an optimal intake of all essential nutrients in the body, which contributes to good health, normal reproduction and high productivity. A significant reduction in the energy deficit during this period can be achieved by introducing energy-rich feed concentrates, grass cutting and grass flour of high quality, root crops, etc. into the diet. The higher the milk yield of cows, the more energy should be in one kilogram of dry matter of the diet. The morbidity of farm animals can be controlled by introducing a protein-vitamin concentrate into animal feed. We are looking for ways to stabilize morbidity and increase weight gain and milk yield. We believe that one of the ways to solve this problem is to improve the technology of feeding farm
animals by adding to the diet a protein-vitamin concentrate with improved taste and nutritional properties.

5. References
[1] Kambulov S I, Bozhko I V and Olshevskaya A V 2018 MATEC Web of Conferences 224, 05022 https://doi.org/10.1051/matecconf/201822405022
[2] Lachuga Y, Soloviev A, Matrosov A, Panfilov I, Pakhomov V and Rudoy D 2019 IOP Conf. Series: Earth and Environmental Science 403 012055 IOP Publishing doi:10.1088/1755-1315/403/1/012055
[3] Zhurba V, Chayka Y, Gucheva N, Ushakov D, Ugrekhelidze N, Kulikova N and Egyan M 2019 E3S Web of Conferences 135, 01087 ITESE-2019 https://doi.org/10.1051/e3sconf/201913501087 123
[4] Kokieva G E, Voinash S A, Sokolova V A and Fedyaev A A 2020 The study of soil mechanics and intensification of agriculture IOP Conference Series: Earth and Environmental Science 548(6), 062036
[5] Rudov S, Shapiro V, Grigorev I, Bondarenko A and Radnaed D 2019 Specific features of influence of propulsion plants of the wheel-tyre tractors upon the cryomorphic soils, soils, and soil grounds International Journal of Civil Engineering and Technology 10(1), pp. 2052-2071
[6] Druzyanova Y A, Kokieva V P, Nifontov K R and Sidorov M N 2018 The increasing of work efficiency of mixing machines PeriodicoTcheQuimica 15(1), pp. 67-76
[7] Ivanov V V, Popov S I, Dontsov N S, Ekinil G E, Oleynikova Ju A, Denisenko Ju N 2020 Mechanical coating formed under conditions of vibration exposure XIII International Scientific and Practical Conference «State and Prospects for the Development of Agribusiness – INTERAGROMASH 2020»: E3S Web of Conferences, 175, pp. 05023 doi.org/10.1051/e3sconf/202017505023
[8] Altybayev A, Zhanbyrbayev A, Meskhi B, Rudoy D, Olshevskaya A and Prohorova A 2019 E3S Web of Conferences 135, 01078 https://doi.org/10.1051/e3sconf/201913501078
[9] Parkhomenko G, Kambulov S, Olshevskaya A, Babadzhanyan A, Gucheva N, Mekhantseva I 2019 IOP Conf. Series: Earth and Environmental Science 403, 012144 IOP Publishing doi:10.1088/1755-1315/403/1/012144
[10] Bozhko I, Parkhomenko G, Kambulov S, Boyko A, Kolodkin V, Magomedov M and Rudoy D 2020 E3S Web of Conferences 175, 05025 INTERAGROMASH 2020 https://doi.org/10.1051/e3sconf/202017505025
[11] A Zavaliy, S Volozhaninov, O Shitian1, D Rudoy and A Olshevskaya 2020 E3S Web of Conferences 175, 05003 INTERAGROMASH 2020 https://doi.org/10.1051/e3sconf/202017505003
[12] Mazanko M, Prazdnova E, Rudoy D, Ermakov A, Olshevskaya A and Maltseva T 2020 E3S Web of Conferences 175, 01010 INTERAGROMASH 2020 https://doi.org/10.1051/e3sconf/202017501010
[13] Parkhomenko G, Bozhko I, Kambulov S, Boyko A, Polushkin O, Lebedenko V, Beskopilniy A and Olshevskaya A 2020 E3S Web of Conferences 175, 09006 INTERAGROMASH 2020 https://doi.org/10.1051/e3sconf/202017509006
[14] Nesmiyan A, Kravchenko L, Khizhnyak V and Zubrilina E 2020 E3S Web of Conferences 175, 05019 INTERAGROMASH 2020
[15] Meskhi B, Golev B, Efros V, Rudoy D, Olshevskaya A, Zhurba V and Chayka Y 2019 E3S Web of Conferences 135, 01083 ITESE-2019 https://doi.org/10.1051/e3sconf/201913501083