Increase of Animal Products by Means of Complete Feed Provision

A G Cherkashina¹, S V Stepanova¹, A V Spiridonova², R G Kalininsky³

¹Federal State Budgetary Educational Institution of Higher Education "Arctic State Agrotechnological University"; 677007, Russia, Yakutsk, Sergelyakhskoe highway 3 km., Building 3
²Federal State Autonomous Educational Institution of Higher Education "North-Eastern Federal University named after M. K. Ammosov", 677000, Russia, Yakutsk, st. Belinsky, 58
³JSC "Roads of Ust-Aldan"

E-mail: Kokievagalia@mail.ru, savadfo706@mail.ru, kroman72@mail.ru

Abstract: To increase the amount of animal products manufactured, it is required to meet the needs of animals not only in the energy and nutrients but also in the biologically active components improving the fodder productive effect (enzymic preparation, vitamins, microelements, etc.). In most cases the action of biologically active agents applied in live stock breeding is reduced to the activation or inhibition of one or another enzymatic process. Exogenous ferments, recommended today for the application in livestock breeding, are used in two ways. These are the fermentation of ration ingredients before animal feeding and their injection into the digestive tract as part of the ration (combined feeds, premixes). Each of the considered methods has its advantages and drawbacks with the account of the enzyme preparations processability and properties. The complete feeding of dairy cows stipulates for the optimal intake of all necessary nutrients in the organism which promotes good health, normal reproduction and high performance. A significant reduction of energy deficiency for this period can be obtained by the ration addition with the fodders rich in concentrate energy, high quality grass chop and grass meal, tuberous roots, etc. The higher milk yield is, more energy a kilo of dry ration matter should contain. The article suggest a technology for obtaining fodder protein&vitamin concentrate for complete feeding of live stock animals.

1. Introduction

The agricultural reforms and building a dual economy in the village with various ownership forms for capital equipment induced the upgrade of AIC infrastructure, in particular, the system of resource allocation. Its organizational structure underwent dramatical changes while the main material resources were derived from the centrally-controlled distribution into the area of direct horizontal links interconnections between consumers and manufacturers. Interfarm manufacturing and agroindustrial companies and unions are organized taking into account territorial and sectoral characteristics. By the sectoral characteristics, interfarm companies and unions are organized to manufacture the products in a certain sector both within one and several administrative districts or even a region. In particular, research and production associations built on this basis include organizations on selection and seed farming, breeding, production of some types of agricultural products. In Yakutia work on cattle
quality improvement started in the 30-s of the XXth century. 1932 was the start of routine replacement of the local live stock by the Kholmogory and Simmental breeds by cross-breeding. In this connection, a need raised to conduct selection & stock breeding. Gradually, the breed content and live stock breed were being changed. In the Yakutia conditions the process of beef cattle breed improvement has its peculiarities and is rather long-term. Cow artificial insemination accelerated the process of breed transformation. The Simmental live stock in Yakutia is more stocky and heavy-boned then the conspecific animals from the Russian Far East. The Simmental animals have a robust build, strong skeleton and well-developed muscles. The main colors of the Simmental animals: straw-colored, straw-colored with spots, sometimes red and white/ red with a white head. Purebred Simmental animals have light pink rhinoscope, tongue, pharynx and eyelids. As a rule, the Simmental cows are large (height at crest 135-140 cm), well-proportionate (cross body length 160-165 cm), with a strong skeleton (metacarpus grasp 20-21 cm); big head wide in in the front part; medium length neck; deep chest (68-72 cm), wide (45-47 cm), the bulls have a well-developed jowl; wide back; the hindquarter is long and wide; the sacrum is sometimes elevated; strong skeleton; well-developed muscular system; legs are generally set in a right position; thick skin; the dug is oftentimes round, with a large volume and soft hair; big nipples, cone or cylindrical. The Simmental animals comprise 82% of a total number of beef cattle in Yakutia. It is built by means of selection and pick-up of the best live stock animals of universal yield (meat, milk and working performance).

2. Research methodology
At present there are 45 organizations from various companies, 165 peasant farms, 2,371 personal farms are operating in the nomad camp; in addition, there are 43 agricultural consumer cooperatives and 10 agricultural credit unions. A total area of agricultural lands comprises only 89,751 hectares, including 6,320 hectares of croplands, 26,809 hectares of hayfields, 27,794 hectares of pastures. Improving the efficiency of animal product manufacturing is possible by means of the development of the mechanical & technological basics of protein & vitamin concentrate by agricultural facilities.

In organizational and technical terms the households develop the key issues of the fodder base creation. The fodder base should surpass the needs of beef cattle and horse population as well as provide for the creation of necessary feed reserves as this is an essential need. The main economic sector of the nomad camp is agriculture. Although live stock breeding is labour-consuming, it is also traditionally wide-spread and significant activity for the district economy. For the nomad camp this is also a socially important activity as the extension of milk and meat cattle breeding provides essential food products and jobs to the population.

Unfortunately, the last decade resulted in a dramatic reduction in the live stock population. In 2010 we were able to gain the beef cattle growth by 51 animals, horses by 280 animals, pigs by 14 animals, birds by 163 capita. Today the nomad camp has 3 agricultural companies, 45 peasant farms and one procurement organization - Abyjagroprom, MUE (MUP). In 2016 the improvement was observed in manufacturing of the essential industrial products, food and non-food items. As a result of the tedious work of rural population, today the nomad camp is self-sustained producing fish and meat products.

Our purpose is to increase the live stock population, number of families breeding live stock, pigs and birds. Now the preparatory work on the implementation of the Federal Law FZ-88 “On Technical Regulations for Milk and Dairy Products” is in progress. The processing centers are being built: dairy processing units in Abyjsky and Mugurdakhsky communities, fish processing units in the Urasalakhsky community. Due to the interaction and support of the Ministry of Agriculture and Food Policy of the Republic of Sakha (Yakutia), Ministry of Finance of the Republic of Sakha (Yakutia) in 2016 110 tonnes of additional fodder and potato were transported by sea. For the last five years 20 residential houses were built in the villages by the national project “AIC Development” alongside with the conduct of reclamation works for the help of 2 million rubles due to which the villages acquired 9 tractors, burans and outboard motors. Two horse bases were built.

The peasant farming household “SARGY” is specialized in live stock breeding and comprises beef cattle of the Simmental breed. They are rather suitable for natural & climatic conditions of the North,
easy-going about food and living conditions, make use of pastures well. The peasant farming household “Sargy” was organized in 2006 and is located in the territory of the Abyj village. The peasant farming is directed at meat and milk production and relates to the live stock breeding type of households. All beef cattle is kept in a primitive cow shed of the Yakutia type. Cattle house in the farming household is semi-mechanical and equipped with water trough, foddering and manure management are done manually. In summer animals are held in the “sajlyks”, summer settlements where they are kept on loose housing and pasture management. No milking machines are available, milking is done manually. The household has 11 capita of beef cattle, since 2015 the population reduced twice. If the cow is fed and kept well during the interlactation period the cow fertilization rate increases. Otherwise, the animal with good productive qualities can be milked until its calving. To eliminate the fodder deficiency, the authors suggest the technology for obtaining fodder protein by means of microbial synthesis in the new design equipment. Figure 1 presents the microbial synthesis equipment.

The mixer has a bladed triple-deck mixing device which induces a higher turbulence of liquid flow and facilitates medium mixture throughout the machine. Such design intensifies the mixing and improves the quality of products.

![Figure 1](image)

**Figure 1.** Microbial synthesis equipment: $H$ – fermentor height; $H_0$ – liquid elevation; $h_1$ - distance between mixing devices; $h_0$ – distance from the lower mixing device to the bottom; $d_m$ – mixing device diameter; $D$ – fermentor diameter; $b$ – mixing device blade width; $l$ – mixing device blade length; $C$ – baffle width.

The studied mixing devices provide full and uniform distribution of the particles throughout all the medium mixed as well as the design simplicity, convenience and leak-tightness. The main research objective is to identify the efficient mode of the mixing device operation.

Table 1 provides the cultivation data for the equipment.
### Table 1. Cultivation data in the equipment.

| No. | Cultivation time | µmax Biomass accumulation, billion/ml | Optical density | Number of viable cells | Minimum generation time gmin, h | Glucose content for the cultivating time, ml |
|-----|------------------|-------------------------------------|----------------|------------------------|-------------------------------|---------------------------------------------|
|     |                  |                                     |                |                        |                               |                                             |
| 1   | 14               | 1.3±0.01                            | 0.9±0.004      | 5.4±0.15               | 4.8±0.01                      | 0.6±0.1                                    | 35.4                                       |
| 2   | 12               | 1.1±0.07                            | 0.98±0.05      | 6.7±0.2                | 5.9±0.21                      | 0.71±0.01                                 | 36.2                                       |

Instructive mode

|     |                  |                                     |                |                        |                               |                                             |
| 3   | 14               | 1.14±0.03                            | 0.77±0.33      | 15.4±0.4              | 14.2±0.35                     | 1.0±0.01                                  | 330.20                                    |
| 4   | 12               | 0.1±0.02                            | 0.92±0.02      | 20.4±0.45             | 15.4±0.4                      | 0.82±0.01                                | 280.14                                    |
| 5   | 9                | 0.47±0.02                           | 0.01±0.0001    | 8.4±0.3               | 4.0±0.02                      | 0.9±0.01                                 | 129.18                                    |
| 6   | 10               | 0.711±0.03                           | 0.62±0.02      | 12.9±0.04             | 5.0±0.1                       | 1.62±0.02                               | 150.00                                    |

Experimental mode

3. Research essentials

During the microorganism cultivation foam occurs on the surface of the cultural medium. The foamy bubble diameter $d_p$ is defined by the size of holes in a bubbling chamber and physical&chemical properties of the cultural liquid:

$$d_p = \sqrt[3]{\frac{6d_0\varnothing}{q(p_\text{ж} - p_r)}}$$

(1)

where: $d$ – hole diameter;
$\varnothing$ – surface tension;
$q$ – gravitational acceleration;
$p_\text{ж}$ – liquid density;
$p_r$ – gas density.

In this case, the number of bubbles:

$$n = \frac{6V_r}{\pi d_p^3}$$

(2)

where $V_r$ – total volumetric air rate under normal conditions.

At the research of oxygen sorption in the culture media with various viscosities to calculate gas content the following equation is taken:

$$\varphi \left(\frac{1}{1 - \varphi}\right)^4 = 0.2 \left(\frac{D^2 p_\text{ж} \varnothing}{\sigma}\right)^{0.62} * \left(\frac{D^2 p_\text{ж}^2 \varnothing}{\sigma \mu_\text{ж}}\right)^{1/2} * \frac{W_r}{(D \varnothing)^{8.5}}$$

(3)

where $D$ – apparatus diameter.

By today, the scientists have already conducted systematic research [5-8] and provided recommendations to define $\varphi$ with the following dependence:

$$\varphi = \frac{1}{2+\left(\frac{0.15}{W_c}\right)^3\left(\frac{\varnothing}{\sigma}\right)^{1/3}}$$

(4)

At the research of gas content in the recirculation column with the diameter $\varnothing = 0.15$ m and the height $H = 10.5$ m the authors [4, 7] obtained the following equation:

$$\varphi = W_c (0.24 + 1.35 W_c 0.93)^{-1}$$

(5)

According to [9, 10], at the research conducted for the machine model made of glass tubes $3$ m high, the diameters $0.055; 0.08$ and $0.11$ m, the authors obtained the dependence which allows defining the liquid speed in transport airlifts (gaslifts):

$$W_{ж} = \sqrt{\frac{2 \varphi H}{\xi} \left(\frac{n}{\mu} - 1 + \varphi_c \varphi \right) \left(1 - \varphi \varphi_c\right)^2}$$

(6)
Here $\xi$ – aggregate hydraulic airlift resistance equal to:

$$\xi = 0.5 + \frac{H}{d} \left(1 - \varphi_0\right) 0.5 \left(1 - \varphi_0\right) 0.5 +\left(1 - \varphi_0\right) 0.2,$$

(7)

where: $\lambda$ – pipe friction factor at the same specific speed of liquid flow inside the pipe;

$\varphi_0$ – gas content at the liquid outlet from the airlift.

For the calculation of $W_\omega$, using the data [3, 11-14], it is recommended to apply Bernoulli’s equation transformed for the circulation circuit of the following form:

$$H(p_w - p_r) \varphi^* g = \Delta P_0 + \Delta P_a$$

(8)

At the moment the process of feed protein manufacture during the microorganism cultivation in a cultural liquid a number of reactions occurs in a fermentation liquid with oxygen. A number of authors [7, 11] recommended using the following dependence for the oxygen reactions with liquids widely applied in the industry to calculate $W_\omega$:

$$H(p_w - p_r) \varphi^* g = \left[1.5 + \lambda_u \frac{M}{d_u} \left(\frac{L}{f_a}\right)^2 + 2 + \frac{1}{(1-\varphi)^2} \frac{\lambda_u M}{(1-\varphi)^2 f_a d_a} \right] \frac{\rho_w M}{2} \frac{\Delta P}{\rho_r}.$$

(9)

The calculation is conducted by means of approximation by one of the selected equations which suit for defining the gas content in the cultural medium. At the pressure to 4 MPa on the medium with the properties close to the system “water-air” and the ratio of the bubbling chamber and circulation areas $f_o f_w = 1$ close to the value of the liquid specific velocity, the authors also suggest calculating $W_\omega$ by a simplified equation:

$$W_\omega = 3.5 \left[\frac{H \beta}{\xi k} \left(\frac{\Delta P}{\rho_r}\right) 0.125 \right]^{0.5}$$

(10)

where $\xi = 5.1 + 0.03 \left(\frac{H}{d_o} + \frac{H}{d_u}\right)$ – circulation circuit resistance factor.

Air films occur on the air bubble surface of the gas-liquid interface. They pass through the culture, hinder oxygen diffusion throughout the fermentor and decrease the resistance formed.

The research of oxygen absorption processes in fermenters is considered in a range of papers [1, 7, 11].

If considering the case at poorly soluble gas (oxygen), the values $m_p$ and $K_a$ are high, and hence the diffusion resistance in the gaseous phase can be neglected; thus, the inequation is observed:

$$\frac{1}{K_{la}} \gg \frac{1}{K_m p_c},$$

(11)

Whence it follows that:

$$k \approx k_{la}$$

(12)

On the basis of the equation $k \approx k_{la}$ the mass-transfer equation: $\frac{dc}{dy} = K_1 \cdot \alpha (C_p - C) - K_5 x$, for the speed of oxygen solution, to absorb air oxygen with a culture liquid, will be written as follows:

$$\frac{d^2 M}{dv_p dt} = K_L \alpha (C_p - C).$$

(13)

The predictability and efficiency of the applied numerical methods allow conducting further modification for the calculation technology including the selection of turbulence models to improve the calculations precision.

Figure 1 provides a diagram of theoretical and experimental dependence of the experimental fermentor on the substrate density with the account of the correction coefficient $K= 0.85 - Q_{recop}$ at constant variables: oxygen specific consumption ($x_2 = 0.71$, $r = 0.04$ $m^3/m^3$ sec) and the mixing device shaft rotations ($x_1 = 1.36$, n = 73 rpm).

The criterion $t = 3.259 < 3.707$ (critical) at the significance level 0.01, i.e., independent samples belong to one set at the significance level 0.05 $p > 0.01$. The significance level of the obtained results (F – criterion) $p = 0.805 > 0.75$, i.e., the correlation of theoretical and experimental data is good, $p = 0.805 > 0.75$. 

\[\textbf{Figure 1}.\]
Figure 2. Diagram of theoretical and experimental dependence of the experimental fermentor on the substrate density with the account of the correction coefficient $K = 0.85 \cdot Q_{\text{теор}}$ at constant variables: oxygen specific consumption ($x_2 = 0.71$, $r = 0.04 \text{ m}^3/\text{m}^3\text{ sec}$) and the mixing device shaft rotations ($x_1 = 1.36$, $n = 73 \text{ rpm}$).

Figure 1 clearly shows well correlating theoretical and experimental dependences. The analysis of the results of a multi-factor experiment allowed substantiating the mathematical model of the fermentator performance in the form:

$$Q = K \cdot 0.248 \cdot 10^{-2} \cdot V_p \cdot (51.6 + 0.63 \cdot x_1 + 7.29 \cdot x_2 + 4.70 \cdot x_3 - 0.0055 \cdot x_1^2 - 0.072 \cdot x_2^2 - 0.045 \cdot x_3^2 - 0.0012 \cdot x_1 \cdot x_3 - 0.00078 \cdot x_2 \cdot x_3), \text{ kg/day},$$

(14)

where $K$ – corrective factor, $K = 0.85$; $V_p$ – reactor volume, $\text{m}^3$; $x_2 = r^{0.105}$, where $r$ – specific oxygen consumption, $\text{m}^3/\text{m}^3\text{ sec}$; $x_3 = \rho^{0.58}$, $\rho$ – substrate bulk weight, $\text{m}^3$; $x_1 = n^{0.07}$, $n$ – number of rotations of the mixing device shaft, rpm (variable values raised to the power are defined with online calculator in the Internet).

To feed cows, it is reasonable to use complete feed mixtures which contain all necessary nutrients. As a result, cow milk yield increases by 13-15% and the feed efficiency decreases by 7-10%. The cow milk yield is mostly defined by the ration provision with complete protein. The rate of digestible protein per 1 feed unit is 95 g at the day milk yield up to 10 kg of milk and gradually increases up to 105 – 110 g at the milk yield 20 kg and more.

Table 2 gives the analysis of the beef cattle stock.

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

The actual calves accretion is 27% (this means that each year the pregnancy percentage decreases as the cow insemination is poorly conducted), the milk yield is 1,124 hwt on average per lactation. The milk produced equaled 4,670 kg which is 17.6% less comparing with 2017. Recently the peasant farms have demonstrated the reduction in cow stock by 48% which is a significant number for small
farming. Because of the cow stock reduction the corresponding reduction in gross and commodity product output by 10% on average (Table 3).

**Table 3.** Farm business performance.

| Indicators                  | Unit  | 2014 | 2015 | 2016 | 2017 | 2018 |
|-----------------------------|-------|------|------|------|------|------|
| Number of cows              | animal| 25   | 22   | 15   | 12   | 11   |
| Milk yield per 1 forage-fed cow | kg    | 1,158| 1,145| 1,156| 1,134| 1,124|
| Actual calves accretion     | %     | 40   | 45   | 40   | 25   | 27   |
| Milk produced               | kg    | 12,738| 10,305| 6,936| 5,670| 4,670|
| Gross                       | hwt   | 148.8| 103.9| 81.9 | 60.1 | 50.1 |
| commodity                   | hwt   | 99.3 | 86.4 | 72.0 | 54.3 | 44.3 |

The winter ration of cows should consist of bulky feed. The optimal amount of hay for dairy cows is 1.7-2 kg per 100 kg of animal live weight. To provide the animals with vitamin R, the hay feed should be at least 1.6 - 2 kg of their weight. It is recommended to introduce silage into the cow ration at a rate of 3-4 kg per 100 kg of live weight. Fodder root crops – 1.0 – 1.5 kg of milk. Concentrated feed - 250-350 g per kg of milk. The research conducted established that the obtained protein inclusion into the ration increased milk yields, weight gain, physiological peculiarities.

4. Conclusion

Microbial synthesis in the various scale machines expressed in terms of the volume units of the obtained product amount (biomass or metabolism products) will be similar or virtually similar in the various scale machines. The complete feeding of dairy cows stipulates for the optimal intake of all necessary nutrients in the organism, which promotes good health, normal reproduction and high performance. A significant reduction of energy deficiency for this period can be obtained by the ration addition with the fodders rich in concentrate energy, high quality grass chop and grass meal, tuberous roots, etc. The higher milk yield is, more energy a kilo of dry ration matter should contain. Live stock animal morbidity can be controlled by means of introduction of the protein&vitamin concentrate into the animal fodder. We are searching for the ways of morbidity rate stabilization and improving weight gain and milk yields. One of the ways of this problem solution is assumingly the enhancement of live stock feeding technologies by means of adding protein&vitamin concentrate with improved flavor and nutrition properties.

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