Innovation and Technological Development of the Feed Industry

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Abstract. This paper dwells upon the key factors of innovation and technological development in the feed industry. Today’s livestock farming builds upon feed use. When livestock is crammed in a small area while living on industrially made feed alone, its health, metabolism, and productivity degrade. The proposed technology for making well-composed feed blocks will boost the profits from selling the products while also improving the daily average weight gain in cattle. The obtained data are in favor of adding the feed additive to the cattle nutrition.

1. Introduction

Feed production must improve, as must the grain quality, if the livestock production is to rise rapidly and cost-effectively [1, 2, 3]. Cutting-edge technology helps considerable improve the quality of feed [4, 5, 15]. Use of properly composed feed boosts animal productivity [16]. Today, well-balanced feed only accounts for 25% of feed produced in Russia [6].

The theory for this research was based on scientific advancements in the socioeconomic development research on the agroindustrial complex, in particular on feed and feed additive markets. This is a relevant research area covered by Russian and international scientists: V.V. Kafarov, I.V. Kulakovsky, F.S. Kirpichnikov, Ye.I. Reznik, A.V. Bondarenko, O.S. Korneyev, V.I. Fisinin, S.A. Abram, P.M. Davil, etc.

The paper dwells upon the feed market. Focus is made on feed additives, as high-quality safe livestock and poultry meat, whether raw or processed, cannot me produced without special additives that improve feed conversion without jeopardizing the livestock. Described herein is an attempt to comprehensively analyze the innovation and technological development of the feed industry, as well as the prospects of this market.

2. Material and methods

The methodology was chosen on the bases of sufficiency, objectivity, reliability, and outlook. The baseline of the study was tailored to the required depth and detailedness of the empirical basis, as well as to meet the reliability and applicability requirements.

Information was sourced from Rosstat statistics and analytics, official data of specialized ministries and agencies, data of information and analysis centers, reports by agencies engaged in agricultural economic research, as well as data from domestic and international markets.

High-performance liquid chromatography, atomic absorption spectroscopy, spectrophotometry, and rheology were used to find the content of vitamins, micronutrients, and other values. Measurement
errors did not exceed the values set in the effective standards for quantitative quality testing of raw materials and finished products [9, 15].

3. Results and discussion
Use of feed additives maximizes the potential animal productivity while reducing the costs of feed, which accounts for about 70% of the total costs. All of this makes the industry more competitive [7, 8, 14]. Global Market Insights predicts the world feed market to reach 17.5 billion US dollars in monetary terms by the end of 2019, 22 billion by 2022. Production of feed additives in Russia rose from 2014 to 2018, see Figure 1.

![Figure 1. Feed additive production in Russia, million tons.](image)

Well-known technologies and equipment cannot produce high-quality feed and attain the desired effect when feeding [9, 10, 18].

To compensate for the shortage of vital nutrients, animals must consume a functionalized product that combines all the necessary components while also being manufacturable and storable [11, 12, 13]. Feed blocks (similar to licks) can combine all the components the livestock industry needs. The need for better feeds and their easier consumption has led to the creation of molasses-based blocks that contain grains as appetizers.

Critical for making such feed blocks is the mixing process, as it is the most energy-intensive stage that determines the quality and storability of the product. A lackluster mixing technique will jeopardize the final quality and necessitate costly improvements so that animals remain healthy while gaining weight. State-of-the-art mixers have been fundamental to scientifically backed novel energy-efficient technologies for making feed blocks that have important energy-saving additions in place [10, 14].

Licking is necessary, which makes licks more important than bulk mixtures; the duration of licking has been proven to correlate with milk production and blood immunoglobulin levels.

A feed block has an optimal composition for cattle feeding; it proves all the necessary vitamins, macronutrients, micronutrients, and carbohydrates. A feed block improves the fed animal’s appetite, regulates its alkaline balance and phosphorus-calcium metabolism while also improving hematopoiesis and immunity.

Figure 2 shows the optimized feed block recipe.
Figure 2. Feed block recipe.

An informal method was used to develop the mathematical model of the mixing process, as the model was tailored to a specific mixer [16, 20]. Input ranges were adjusted using central rotatable uniforming; 56 experiments were run three times each to create regression equations that adequately describe the actual ingredient mixing process as observed when making feed blocks.

The mathematical model of binary composition mixing was based on the following functions:

\[
\frac{d (c_A - m_A)}{dt} = -k (c_A - m_A)^2 + kD_A, \tag{1}
\]

\[
\frac{d (c_B - m_B)}{dt} = -k (c_B - m_B)^2 + kD_B, \tag{2}
\]

where \( k = \mu(N_Aa' + N_Bb')/b' \) is the coefficient; \( c_A, c_B \) are the relative concentrations of the components \( A \) and \( B \); \( m_A, m_B \) are the mathematical expectation values for the concentrations of \( A \) and \( B \) that match the recipe values; \( \mu \) is the proportionality factor; \( N_A, N_B \) are the numbers of \( A \) and \( B \) particle fusions; \( a' = a\gamma_AV_A \); \( b' = b\gamma_BV_B \); \( a \) and \( b \) are the numbers of particles in fusions \( A \) and \( B \); \( V_A \) and \( V_B \) are the volumes of particles type \( A \) and \( B \); \( \gamma_A \) and \( \gamma_B \) are the densities of particles \( A \) and \( B \); \( D_A \) and \( D_B \) are the dispersion values that indicate whether the mixing process is complete.

The mathematical functions improved vitamin preservation and helped produced highly homogeneous feed blocks by using two-stage mixing with reduced impact while also reducing the energy costs thanks to a two-stage heat pump that maximized the recovery and utilization rate of recycled heat carriers in closed thermodynamic cycles. The obtained results were used to design a mixer with a z-shaped implement [18].

The blocks were stored for 12 months in a warehouse and preserved 90.5% of vitamin A, 91.4% of vitamin E, and 90.7% of vitamin B compared to 81.8%, 71.4%, and 70.3% in the controls. While in the warehouse, the products were not altered property-wise, were not spoiled by humidity. Microbiological readings were within acceptable limits. Thus, the recommendable warehouse shelf life is 12 months.

4. Conclusions and recommendations

Additional techniques help implement the proposed technology to save energy and the environment, as the heat carriers have different temperature potentials, are prepared by the heat pump to save energy, and are never released to the environment after use to save the environment. Implementing this technology for making well-composed feed blocks will boost sales by up to 20% in monetary terms. Zootechnical experiments showed this product to improve the daily body gain by 8.1% in cattle.
This effectively brings a competitive technology to the market as well as a feed additive suitable for export.

References

[1] Cheremushkina I V Biotech Cluster as a Criterion of Food Security Formation Contributions to Economics pp 159-166
[2] Cheremushkina I V 2017 Role of Clusters in Promotion of Region’s Economic Competitiveness Contributions to Economics pp 47-54
[3] Modern aspects of the use of renewable natural resources in the technology of food products of functional and specialized purpose: collective monograph N V Pankova: O S (St. Petersburg: Ed. "LEMA") 254 p
[4] Development of enterprises, industries, complexes: innovative view: collective monograph (Odessa: KUPIENKO SV) 149 p
[5] Kravchenko V M 2012 Technology of production of modified fodders with immunotrophic and prebiotic action Journal of Voronezh. Un-that engineer. Technologies 2 pp 113-115
[6] 2015 Commodity management: economic, organizational and managerial aspects: collective monograph Edited by E I Makarov (Voronezh: Ed. polygraph. Scientific Book Center) 237 p
[7] Korneeva O S 2015 Development of Complex Feed Additive International Journal of Applied Engineering Research vol 10 21 pp 42737-42742
[8] Cheremushkina I V 2017 Innovative biotechnology probiotic feed additives and immunostimulatory effects Research Journal of Pharmacy and Technology vol 10 4 River of 1165-1167
[9] Lytkin L I 2013 Implementation of energy-efficient technology of mixed feeders as a system of thermal and mechanical processes Journal of the Voronezh State University of Engineering Technology 4 pp 56 – 61
[10] Lytkin L I 2016 Probabilistic model of the process of mixing ingredients of mixed feeders in the mixer-reactor of continuous action Journal of the Voronezh State University of Engineering Technologies 2 pp 16 – 21
[11] Cheremushkina I V 2013 Resource-saving in the production technology of a prebiotic biological product for agrarian and industrial complex - as a basis of increase in cost efficiency Finance, economy, strategy 9 pp 31-33
[12] Cheremushkina I V 2015 Extraction of mannan from plant raw materials Research Journal of Pharmaceutical, Biological and Chemical Sciences vol 6 1 pp 1634-1639
[13] Pat. # 2512908 Method of fodder production (Opubl. In B.I.) 2014 10
[14] Pat. # 2612783 Method of producing a coma additive (Opubl. In B.I.) 2017 8
[15] Shentsova E S 2014 Theoretical estimation of permissible limits of errors of BAB content in premixes Agrarian science 12 pp 25 - 27
[16] Kravchenko V M 2011 Development of the method of production of mixed fodder with prebiotic action Storage and processing of agricultural waste 11 pp 67
[17] Shentsova E S 2016 Selection of rational parameters of technological conditions of mixing process when obtaining feed briquettes Journal of the Voronezh State University of Engineering Technologies 3 pp 61 – 67
[18] Apalichina O A, Inverzeva S A, Sazonov S I, Shevtsov A A, Lytkin L I Useful model 171698 Mixer Opubl. 13.06.2017 Bul 17
[19] Cheremushkin I V 2013 Safety of food raw materials and food products (Voronezh. state. Un-engineer. Technologies) Voronezh: VGUIT 117 p
[20] Zhuchkov A V 2013 Mathematical modeling of the process of drying modified fodder Journal Voronezh. State Engineer. Technologies 2(56) pp 100-105