Biotechnological Processes Digitalization in Animal Husbandry

Levkina Ruslana, Levkin Arthur, Petrenko Anna, Kolomiets Nataliya

Abstract— The article analyzes the agrarian enterprises business processes management and enterprises which providing their activity, based on the digitization technologies and other innovative solutions. High rates of technological and technological upgrades for their implementation require constant monitoring and implementation of innovative solutions in the agricultural management field and established economic links with organizations, which create and spread such innovations.

The innovation implementation in a broad sense contributes to the labor productivity growth, saving resources, reducing costs, increasing production and sales, and improving efficiency.

Authors propose to consider the digitalization technologies application in embryo transplant enterprises (laboratories) that provide agricultural enterprises with cattle embryos. The software, in combination with the biotechnology laser embryo division system, allows authors to automate the process and ensure its high quality, and the mathematical model formalization - to transfer the process methodology to almost all areas of animal husbandry. The result within Ukraine is the livestock herds restoration and higher productivity level transition in the direction of the slaughter weight and milk yield increasing, and improving the corresponding indicators of enterprises, industry, economy of the country. Such technologies form the requirements for agrarian management system, a qualitatively new level of professional education and behavior of specialists, which motivates to the end result. The formation of the agrarian management system as a whole requires the dititalization tools involvement in the process of innovations implementation. Thus, embryo transplant enterprises (laboratories) can and should make extensive use in addition to special (surgical) equipment and state-of-the-art laser equipment, digital equipment, software, IT tools. The state of embryo transplantation technologies development in animal husbandry and its improvement possibility through biotechnological processes automation and digitization with the use of a laser embryo division system allows to increase the process' quality indicators. Algorithms that visualize the process of laser control and laser beam focusing are implemented by computer software. It is the "brain" of the biotechnological system and requires optimization of all system components' parameters.

Therefore, authors have solved the problem of technical means operating parameters optimization by biotechnological process utomation and digitization means of elite farm animals' embryos laser division.

The research results practical significance, proposed methods, mathematical models and tools is to create the conditions for the industrial breeding technology implementation and reproduction Ukraine's livestock.

In fact, the digitization of this process in the sense of device control that improves the embryo fission quality by implementing algorithms for laser beam control visualization and focusing accuracy.

At the corporate executives' level, there is an awareness of the importance and expanded production regularity, increasing profitability through the innovations implementation, whose key function in the agrarian management system is to create conditions for innovative receptivity to all types innovations' implementation, including digital technologies.

Keywords: biotechnological processes, business processes management, dididtalization, agricultural management.

I. INTRODUCTION

Formulation of the problem.

Improvement of agricultural enterprises business processes is obtained by providing them with the necessary material and intangible (including information) resources and building a system of produced products distribution; provision of transport, packing, consulting and other services, envisages their digitization. Digital technologies at all chain stages, from the production process preparation to the marketing process implementation, allow agricultural enterprises to maintain a competitive position at the market. However, the high rates of technologies updating and the implementation technical means require constant monitoring and implementation of innovative solutions on the agrarian management field and established economic links with organizations that create and disseminate innovations. Development dynamics of technical, information-communication and economic spheres determines their complementarity and corresponding formation competencies among the main specialists, management middle agrarian enterprises specialists not only in strategic development understanding, but also in the possibilities innovations using in the agro-industrial production sphere. These are embryo transplant enterprises (laboratories) that, in addition to special (surgical) equipment, can and should make extensive use of cutting-edge laser equipment, digital equipment, software, and IT tools. Considering the long-lasting industrial relations between them, the foundation is being formed to gain the competitive advantages of the agricultural enterprise in the future by optimizing business processes, significantly

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products quality improving, the income level increasing really quickly. As domestic agricultural enterprises do not have a high level of innovation activity, their stable and competitive functioning in the long run is not possible without the innovative development of other institutions in connection with research institutes, laboratories and centers. The innovations implementation in a broad sense contributes to the labor productivity growth, saving resources, reducing production cost, increasing sales, improving efficiency [1]. For livestock enterprises, the result of such innovations is usually the restoration of livestock herds and the transition to higher levels of productivity towards increasing the slaughter weight, milk yields and relevant indicators, which is not possible without strict adherence to the latest technologies. Such technologies form the requirements for agrarian management system, a qualitatively new level of professional education and specialists' behavior, which motivates agrarian enterprises and enterprises (laboratories) for transplantation of cattle embryos in hight results. Therefore, in the formation of agrarian management system as a whole it is important to involve the digitization tools to the process of innovations implementation.

Considering the current level of embryo transplantation technologies development in animal husbandry and its improvement possibility through biotechnological processes automation and digitization, such innovations as the embryos laser division system usage, laser radiation source consisting, collimating optics device to the process quality improvement. This device provides the functions of biotechnological process digitization and the quality management (viability) of resources (cattle embryos) for agricultural enterprises. At this stage of scientific and technological progress development and the country's technological organization level, the algorithms implementation that visualize the laser control process and the laser beam focusing accuracy, implements computer technology software. It is the "brain" of the biotechnological system and requires optimization of all its components.

In such circumstances, the problem is to optimize the operating parameters of technical means by automating and digitizing the embryos' laser division biotechnological process for elite farm animals. The thermal stability (viability) of the resulting embryo portions is ensured by controlling the moving radiation source parameters and the embryo's temperature field limitations.

II. ANALYSIS OF RESENT RESEARCH AND PUBLICATIONS

The basic theoretical and methodological positions related to the nature disclosure and innovations, innovation processes and innovation activities content, peculiarities and patterns of their manifestation in agricultural enterprises were investigated in the works of scientists. For the first time the innovation problems were considered by M. Tugan-Baranovsky and Austrian scientist Y. Schumpeter, continued by B. Santo and B. Twis. Theoretical and practical aspects in the innovations field were covered in the works of their followers: Yu. Atamanova, S. Valdaitsev, V. Vasilenko, O. Volkov, S. Volodin, V. Geets, V. Gusev, O. Datsiy, M. Denysenko, P. Zavlin, M. Zubets, S. Ilyashenko, M. Yokhno, M. Kisil, V. Kondratov - Didenko, M. Koretsky, N. Krasnokutskaya, I.Mikhailova, A.Muzichenko, P. Sabluk, M. Sadikov, V. Semynozhenko, V. Stadnik, O. Teletov, S. Turchina, I. Ushachev, V. Fedorenko, L. Fedulov, D. Chervanov, V. Chizhov, V. Shmatko and others [2]. Basic researches in the field of digitalisation and business process management, IT tools implementation was carried out by the following scientists: R. Rorbeck, N. Tom, H. Arnold, A. Fleischman, which, unfortunately, have a relatively weak connection with the enterprises' industry specialization. Despite numerous scientific researches, there are still many debated and unresolved questions regarding the systematic methodological combined approach of the innovations usage in the agricultural enterprises digitization sphere. However, the specific results of scientific research that can be used for information systems implementation and software products in agricultural enterprises activities of livestock specialization and their logistics, have already been proposed by domestic scientists and have been approved [3].

Analysis of publications of biotechnological methods implementation in animal husbandry and management of the preparation and carrying out process of micromanipulations with cattle embryos to use them for obtaining high productivity milk and live weight yield animals. Such micromanipulations with the usage of moving local energy sources require the mathematical models development on the basis of which the biotechnological process programming takes place. The processes occurring modeling in biological objects during acting on them, for example, by a laser source of energy and IT technologies, in scientific publications have been poorly studied [4 - 7].

III. PRESENTING MAIN MATERIAL

Further development of agrarian management in connection with the usage of the digitization existing infrastructure, networks convergence, services provision and use of scientific and technological achievements, conditioned by technological changes and society transition to a new technological way. The imperative of such development will be to strengthen competition between agricultural enterprises against the available innovative services provided by logistics companies, in our case embryo transplantation enterprises (laboratories) in the complex services packages form for the animals fertilization with their subsequent care and supervision. Awareness of the embryo manipulation value for agricultural businesses requires the effective communications establishment, and the economic processes dynamism that recognizes digital transformation as a business necessity. Instead of manually using microsurgical instruments, laboratories, in their turn, implement a system that runs automatically on the basis of the appropriate software and allows optimizing the embryo cutting biotechnological process for parts that do not lose their viability and have a high survival rate.

Exclusion of risk factors for infection and subjective influence on micromanipulation by specialists indicates the high practical value of the proposals [3].

Previously, our proposals were mainly about micromanipulation with cattle embryos, but they were such that they could be adapted to other conditions, first of all, to other farm animals embryos indicators [8-10]. To meet the need for flexibility and speed of adaptation when laboratories receive orders from industry livestock enterprises, IT companies offer cloud platforms that accelerate application development, workflows, data integration, and empower analytics. These platforms help you build trusted applications without searching the experienced programmers, integration experts, or data analysts. They also make it easier to deploy and manage user-friendly capabilities without much concern about basic infrastructure and security.

The conditions for conducting digitization in transplant laboratories are: its accessibility, speed, clarity for working staff. Considering the essence of the digitalization concept, we understand the deep transformations, digital technologies penetration in business processes' optimization and automation, improving staff productivity and communication with partners, consumers and more. Therefore, in order to implement in practice functioning of laser embryonic division biotechnological systems, in our opinion, it is necessary to develop a mathematical model that allows to describe the process of laser beam trajectory optimization by bioobject. The development of this model and its numerical implementation, taking into account the relevant parameters of the biotechnological system not only allows to increase its efficiency, but can also be used by IT specialists for software packages development for the optical laser radiation automated control.

IV. MATEMATHIC MODEL

Lets formulate a thermal process quality criterion in the embryo when it is divided by a laser source, and the corresponding constraints on variable parameters. The relation between the temperature field and the moving laser radiation source is generally represented as

$$A_T\{\ T[P(x,y,z,t),x,y,z,t]\ \}=0, \qquad (1)$$

where: A_T - a differential operator that describes the distribution of the temperature field, *T(x, y, z, t), x, y, z* - spatial variables, *t* -time, *P(x, y, z, t)* - a function that describes a moving laser source.

Naturally, the corresponding initial and boundary conditions are set [1,2].

The source activity locality is determined by the ratio:

$$P(x,y,z,t)=\begin{cases} P(x,y,z,t), \text{ if } (x,y,z)\in S, \\ 0, \qquad \text{if } (x,y,z)\in\overline{\Omega}\setminus S \end{cases},$$

where: S - carrier of the laser radiation source, $\overline{\Omega}=\Omega\cup\Gamma$, Ω - the embryo's inner points, Γ - the embryo's outer border.

The amount of energy allocated *W* by t_u its activity time is defined as:

$$W=\int_0^{t_u}\int_S P(x,y,z,t)\,ds\,dt, \qquad (2)$$

and source intensity is defined as the integral characteristic of its source:

$$g(t)=\int_S P(x,y,z,t)ds. \qquad (3)$$

The geometric shape of a moving laser source S is characterized by the source type (spot, sphere, elongated in the form of a segment) and its geometrical parameters: the spot or sphere radius, two rectangle sizes for a flat elongated source, three dimensions for a volumetric elongated source, etc.

The law of the source motion is determined by the trajectory $s(t)$ and its motion speed along this trajectory.

On the basis of relation (1), authors formulate a functional formalized value that fits into the process quality definition of embryo laser division, and formalize the constraints on the variable parameters.

As stated in the statement of the main problem, the quality criterion value of the embryo division is to ensure the thermal stability (viability) of the separated embryo parts. This will be ensured if in the technological process of embryo laser division, the maximum value of the embryo's (its parts) temperature field does not exceed a predetermined value, which ensures the embryo parts viability.

Functional quality of the flow of embryo laser devision process is as follows:

$$\Phi=\left|\ \max_{(x,y,z)\in\overline{\Omega},\ t\in[t_0,t^*]} T\ [P(x,y,z,t),x,y,z,t]-T^*\ \right|<\varepsilon \qquad (4)$$

where $T(x,y,z,t)$ - temperature field,

T^* - valid field value,

ε - deviation the temperature field maximum value from the allowable field value set,

$\overline{\Omega}=\Omega\cup\Gamma$, Ω - the inner embryo points,

Γ - the outer embryo border,

x, y, z - spatial variables,

t - time,

t_0 - the process start time,

t^* - the process end time.

Optimality criterion for the laser embryo division process based on the ratio (4) is

$$\left|\ \max_{(x,y,z)\in\overline{\Omega},\ t\in[t0,t^*]} T\ [P(x,y,z,t),x,y,z,t]-T^*\ \right|\Rightarrow\min \qquad (5)$$

Note that in the particular case of the functional (4) quality of the technological process of laser embryo division may be the criterion of not exceeding the temperature field at a given controlled point in advance of a predetermined allowable value. In this case, functional (4) takes the form

$$\Phi=\left|\ T\ (x^*,y^*,z^*,t)-T^*\ \right|<\varepsilon, \qquad (6)$$

where (x^*,y^*,z^*) point of temperature field control.

The optimality criterion in case (6) is

$$\left| T\ (x,^{*} y^{*}, z^{*}, t) - T^{*} \right| \Rightarrow \min$$

Restrictions on process parameters have the following form.

Limitations on laser power

$$W_{\min} \le \int_{0}^{t_u} \int_{S} P(x,y,z,t)dt \le W_{\max}, \qquad (7)$$

where $W_{\min}, W_{\max}$ - respectively the minimum and maximum power values.

A special case of constraint (7) is

$$W_{\min} \le W \le W_{\max}\ , \qquad (8)$$

whre $W = const$.

The limitation on the laser source intensity looks like this

$$, g(t)_{\min} \le \int_{S} P(x,y,z,t)ds \le g(t)_{\max}, \qquad (9)$$

where $g_{\min}, g_{\max}$ - respectively, the minimum and maximum intensity values.

A special case of constraint (9) is

$$g_{\min} \le g \le g_{\max}\ , \qquad (10)$$

where $g = const$.

The constraints on the geometric laser source parameters, for example, for circular or sphere-shaped, have the following form

$$r_{\min} \le r_0 \le r_{\max}, \qquad (11)$$

whre $r_{\min}, r_{\max}$ - respectively, the minimum and maximum source media radius.

In the case where, for example, the carrier is three-dimensional rectangular, then the corresponding minimum and maximum values of its three dimensions are set. x_0, y_0, z_0:

$$x_{\min} \le x_0 \le x_{\max} \qquad (12)$$

$$y_{\min} \le y_0 \le y_{\max} \qquad (13)$$

$$z_{\min} \le z_0 \le z_{\max}. \qquad (14)$$

The restriction on the laser source trajectory is as follows

$$s(t) \in L^{*}, \qquad (15)$$

where L^{*} - multiple trajectories of source motion.

The constraint on the speed $v(t)$ of source movement along the trajectory is as follows:

$$v(t)_{\min} \le v(t) \le v(t)\ x_{\max}, \qquad (16)$$

where: $v(t)_{\min}, v(t)_{\max}$ - respectively the minimum and maximum value of the source's speed.

A special case of constraint (16) is

$$v_{\min} \le v \le v_{\max}, \qquad (17)$$

where $v = const$.

The temperature field gradient restriction from the laser source effect on the embryo is of the form:

$$gradT(x.y.z.t) \le T^{**}, \qquad (18)$$

where T^{**} - the permissible value of the gradient of the temperature field.

The limitation on the temperature field value at a fixed point of field control is as follows:

$$T\ (x,^{*} y^{*}, z^{*}, t) \le T^{*} \qquad (19)$$

where $(x,^{*} y^{*}, z^{*})$ temperature field control point - the temperature field permissible value at the control point.

Note the main **features of the optimization problem** (5) with a set of different constraints (7 - 19).

1. The objective function of problem (5) depends on the temperature field nonlinear distribution in the embryo area, so the optimization problem (5) with a set of constraints (7 - 19) is related to nonlinear problems of mathematical programming of a special form.

2. The problem dimension is determined by the temperature field dimension and the number of variable parameters of the laser source.

3. Since the solution of the optimization problem (5) requires that the parameters of the boundary value problem (source parameters) be determined by the constraints on the temperature field, then this class of problems belongs to the inverse problems of mathematical physics [11].

4. The temperature field is described by a non-stationary boundary value problem for the second-order parabolic type equation, so the optimization problem (5) is related to the systems optimization problems with distributed parameters [11].

5. The functional nonlinearity, non-stationarity of embryo's thermal processes and the presence of parameters constraints included in the boundary value problem - all these features bring this problem beyond the classical problems of optimal systems control with distributed parameters. [11-13].

V. NOVELTY AND PRACTICAL IMPORTANCE

Thus, **for the first time**, the functional quality of the biotechnological process of embryo division by a laser system is formulated, allowing to take into account the basic parameters of this process and to offer its optimality criterion. The formalized parameters constraints system of the laser embryo division biotechnological process provided the opportunity to move to the justification of the technical means operating parameters values, which provides quality embryo division biotechnology based on the laser system. The hardware implementation of the early embryos laser division method in animal husbandry and the software application developed on the basis of a mathematical model of laser beam trajectory optimization on the software bioobject allow to increase the accuracy of focusing.

VI. CONCLUSION

The laser-based biotechnology system not only avoids direct contact of specialists with embryos, but also reduces the number of manipulations and the influence of subjective factors, which contributes to the increase in the number of high-performing calf transplants. The practical significance of the research results, proposed methods, mathematical models and tools is to create the conditions for the industrial breeding technology implementation and reproduction of livestock in Ukraine. In fact, the digitization of this process in the sense of device control, improves the quality of embryo division by implementing algorithms for laser beam control visualization and focusing accuracy.

Most agricultural companies are clearly aware of the importance and regularity of expanding production and increasing profitability through the introduction of innovations, the key function of which in the agricultural management system is to create the conditions for innovative susceptibility to all types innovations, including digital technologies. Ultimately, innovation over time transforms the way itself businesses operate and lead to the effective results of their production and economic activity. The volatility of the external environment requires enterprises to set up a communication flows system and to formulate adequate interpretation and use of information flows to form optimal management and organizational decisions to provide them with the necessary resources. Therefore, awareness of their role as a system catalyst in the economic development strategy implementation is a key task not only for the senior management of any enterprise, in particular agrarian.

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AUTHORS PROFILE

Ruslana Levkin graduated from the Kharkiv Gorky O. State University in 1991 with a degree in Radiophysics and Electronics. Doctor of Economics, majoring in Economics and Management of Enterprises (by type of economic activity), Associate Professor of the Department of Economics and Marketing. She works as the Head of the Department of Entrepreneurship, Trade and Exchange Activity at the Petro Vasylenko Kharkiv National Technical University of Agriculture. The research work is devoted to the research of enterprises' strategic development of different agriculture branches, application of modern innovative approaches to solving problems of their production and marketing activities, finding ways of integration into the world economy and ensuring the economic security of the country. Levkina Ruslana is a member of NGO "All-Ukrainian Congress of Agrarian Economists", scientific director of PhD students. She is editorial board member of the International Professional Journal "Agricultural and Resource Economics: International Scientific E-Journal" and "Topical Issues of Innovative Economics". The main publications are:

1. Levkina R.V., Kravchuk I.I., Sakhno I.V., Kramarenko K.M., Shevchenko A.A. The economic-mathematical model of risk analysis in agriculture In conditions of uncertainty // Financial and credit activity: problems of theory and practice Vol.3, № 30 (2019)/ - P. 248-255/
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Scientific researches Levkin Artur are dedicated to solving the problem of livestock industry development through the use of modern innovative biotechnologies. Such innovations make it possible to ensure the viability of microbial objects when exposed to laser radiation. The objects selected were cattle embryos. A mathematical model has been developed that takes into account the parameters of the biological object and allows to optimize the trajectory of movement of the laser beam in three-dimensional plane and to ensure its viability and engraftment. The model developed forms the basics of biotechnology software and can be formalized to address issues using different types of bio-objects and is of high practical value.

Main scientific works:

1.Levkin A., Levkin D. Constructing an optimization problem of thermal processes at laser distribution embryos in animal. – Motrol. - 2013, Artualnosci Uniwersytetu Przyrodniczego w Lublinie. – pp. 48-56.

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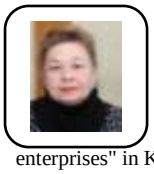
Petrenko Anna In 2009 graduated with honors from the Kharkiv Petro Vasylenko National Technical University of Agriculture in spesiality "Management of Organizations" and received a master's degree in management.. Candidate of Economic Sciences since (PhD) 2014. The dissertation is defended in September 2014, received the diploma of candidate of sciences: series: DK, No. 028010; dated April 28, 2015 Odessa National Academy of Food Technologies, Anna Perenko defended her dissertation in the specialty "Economics and Management of Enterprises (by types of economic activity)". She has been continuously working at the Department of Management as Associate Professor since January 18, 2018. The experience of scientific-pedagogical work in higher educational institutions is 7 years, including at the Kharkiv Technological University "STEP" - 1 year.

It has 26 scientific and educational publications (3 of which are in the Scopus Index). After the dissertation defense, 17 scientific works were published, including 2 publications in Scopus scientific-indexed publications. Received a B2 certificate attesting a sufficiently high level of command of a foreign language (English) in 2018 (Cambrige English Level 1 Certificate in ESOL International (First): Council of Europe Level B2 - April 2018).

Passed a scientific-pedagogical internship at Colorado State University (USA) from July to December 2012. Received the following certificates: Certificate: Attended Agricultural Economics and Agribusiness Courses during the Academic Year 2012-2013 at Colorado State University, USA comprising: Sales Management, International Marketing, Agricultural and Resource Economics, International Trade Certificate in Completing Faculty Exchange Program USDA, July-December 2012.

In 2013, she full-time participated in a conference: 21st Century Business Management Practice and Theory Conference held in Nitra, Slovakia (Nitra, Slovak, 2013), which has been validated by a relevant certificate and scientific by publication. At a high methodical level, he teaches courses in management, marketing, trading, business and innovation.



Kolomiets Nataliya has the following education: first higher education was obtained at the Kharkov Pet Veterinary Institute - in the specialty "Zootechnical Scientist", with this specialty She has worked in production for almost 10 years. Then, she got her second specialty - "Organizer - economist of agricultural enterprises" in Kharkiv Dokuchaev State Agrarian University. After 6 years, she received additional education in the specialty “Organization Manager” in absentia, and obtained the qualification “Master of Management” at Kharkiv State Zoological Veterinary Academy.

She was engaged in research work, studying the need to identify in the conditions of limited investment resources of agroindustrial complex, the search for the most attractive investment objects capable of ensuring the growth of production and economic recovery in the country.

She defended her dissertation on the theme: "Management of investment risk in the field of poultry farming" and received a scientific degree - candidate of economic sciences and in due course received the rank of associate professor. The dissertation uses only those scientific results obtained personally, it is an independent work, which outlines theoretical provisions and methodological recommendations for the assessment of investment risk in financing investments in the meat poultry industry. The published works have been made personal research, which is as follows: the feasibility of integration of enterprises of the meat poultry industry; proved the feasibility of investing in the enterprises of the meat poultry industry; the factors that determine the effective activity of domestic poultry farms are identified, the main directions of improving the efficiency of the meat poultry industry are investigated, the recommendations on financial risk management are given, the new approach to determining the financial risk from investing in the meat poultry enterprises is developed; methodological recommendations for estimation of investment attractiveness of the meat poultry industry are offered, taking into account its potential opportunities in a dynamic environment (developed by the author personally), and approbation was carried out at several enterprises of the meat poultry industry.

Nowadays, she works at the Kharkiv Peter Vasylenko National Technical University of Agriculture at the department "Entrepreneurship, Trade and Exchange Activity". A large number of publications are devoted to disciplines that are read at the department.

The decision of the collegium of the Agrarian Policy Ministry of Ukraine was awarded with the labor award "Badge of Honor".