Neo-industrialization: High Food Processing Technologies in the Sixth Technological Paradigm

Sergey Leonidovich Tikhonov
Ural State University of Economics
Ekaterinburg, Russian Federation
tihonov75@bk.ru

Natalya Valeryevna Tikhonova
Ural State University of Economics
Ekaterinburg, Russian Federation
tihonov75@bk.ru

***Abstract* — The neo-industrial paradigm involves automation of productive forces and introduction of high technologies. A significant value in neo-industrialization is given to innovations that can only be implemented on a high-tech industrial site and advanced automated technologies that allow flexible response to innovations in production schemes. These days the existing technological developments formed as a result of the sixth technological paradigm represent mainly fundamental science and cannot yet be commercialized and used in applied aspects. But at the same time, in the age of neo-industrialization, organizational innovations at industrial enterprises become a significant contribution to the development of the economy, which allows such enterprises to gain a competitive advantage. The mechanism for the implementation of innovations that can ensure the intensification of the use of intellectual assets for neo-industrialization may be actions of large industrial enterprises in the implementation of megaprojects. This institutional matrix will allow to integrate science into high-tech products. One of such organizations introducing innovations is Niagara National Water Company, LLC, one of the top ten leading manufacturers of bottled water and soft drinks in Russia. The company has introduced high-tech technologies and created conditions for their implementation, widespread use in the domestic market and promotion of products for export. An example of the introduction of new high-tech technologies at this enterprise is the development and production of new special beverages for athletes not previously represented in the consumer market. As a result of the technologization of scientific knowledge, we have developed a formulation and technology of a drink for athletes. The biologically active components of the developed drink are silicon and amino acids with branched hydrocarbon chains. Studies show that after 14 months of storage of the drink organoleptic, microbiological, physical and chemical parameters and the content of biologically active substances do not change significantly. It has been established that the reference intake (200 ml of the drink) provides from 72 to 93% of the bodily need for athletes in silicon and up to 95% in AABCC. Based on the studies conducted, the following standard parameters for the quality of the drink, the period and mode of its storage have been established: 12 months at a storage temperature of 0°C to 25°C and a relative humidity of max. 85%. According to the results of the studies, we may observe the cooperation of enterprises with science by means of technological modernization, which is confirmed by the manufacture of new popular competitive products as an example of the neo-industrialization of the industrial sector of the Russian economy in the sixth technological paradigm.**

Keywords* — *new industrialization, the sixth technological paradigm, high technology, food, beverages

I. INTRODUCTION

One of the main priorities of the current discourse is the issue of neo-industrialization - access to a higher stage of the social and economic progress by increasing productivity, raising living and social standards. The neo-industrial paradigm involves the automation of productive forces and, accordingly, the creation of high technologies and the training of workers.

II. REVIEW OF LITERATURE

A specific position in neo-industrialization is held by innovations that are impossible without an industrial basis and advanced automated technologies allowing flexible response to the introduction of innovations into production schemes. Moreover, along with production, related services, customer orientation, flexibility, planning and adaptation are also included in the neo-industrial form of the production process organization. However, at the same time, some researchers, in particular, V.M. Polterovich [1], stated the hypothesis of the innovation pause and the concept of the predominance of the technological branch of scientific and technological progress over the design (innovation) branch proposed by V.G. Klinov [2]. Proceeding from the above: first, the existing technological developments resulting from the sixth technological paradigm represent fundamental science and cannot yet be commercialized and used in applied aspects; second, basically, only those technologies that have been tested at industrial sites are developed, respectively, the trajectory of the old technological paradigm continues, which does not contradict the first hypothesis, where new developments ensuring the advancement of the economy have not yet been used [3], following the development of information technologies that increase labor productivity, freed-up workers with the knowledge of the technological process will be engaged in the area of "knowledge production"

in the high-tech society of the sixth technological paradigm [4]. In the age of neo-industrialization, organizational innovations become a significant contribution to the development of the economy, which allows enterprises to gain a competitive advantage. One of such organizations is Niagara National Water Company, LLC, one of the top ten leading manufacturers of bottled water and soft drinks in Russia. Today, Russia has a sufficient stock of high technologies protected by patents of invention. The creation of conditions for their introduction, widespread use in the domestic market and promotion of products obtained for export is now one of the main tasks of neo-industrialization within the sixth technological paradigm. When considering the global dynamics of patenting, it should be noted that the number of patents will increase significantly in NBIC technologies, including in the field of food biotechnology and in the chemical industry. However, at the same time, it is necessary to take into account the fair opinion of S.D. Bodrunov [4] indicating that in the modern Russian economy there has been a substitution of new technologies with a number of defended theses, published articles and received patents. Due to the current situation, the mechanism for the implementation of inventions that can ensure the intensification of the use of intellectual assets for neo-industrialization may be actions of large industrial enterprises in the implementation of megaprojects. This institutional matrix will allow to integrate science into high-tech products. An example of the introduction of the institutional matrix in the implementation of new high-tech technologies is the development and production of new special drinks for athletes not previously represented in the consumer market.

Today, athlete's training includes 1300–1500 hours per year [5,6], training sessions include 2-3 trainings a day of 2-3 hours each with high competitive loads, so the number of competitions for team sports is 70–85 per year, for swimmers - 100 and for cyclists -150 in average [6].

One of the factors that determines the increase in the effectiveness of the training system in this area is surely a balanced diet and drinking schedule of athletes [7,8]. In this case, sports drinks containing special complexes of amino acids, macro- and microelements, vitamins and vitamin-like substances, along with other essential nutrients, are most popular. In addition, sports drinks restore fluid lost by the body as a result of physical activity. Following the suppression of protein resynthesis during intensive muscular work, the supply of essential amino acids, in particular amino acids with branched carbon chains (AABCC), into the athlete's body should be replenished by feeding, including by using special drinks.

Athletes often pull their muscles and injure ligaments during the training. One of the factors that prevent injuries is the additional supply to the athlete's body of a trace element such as silicon, necessary for adhesion of collagen and elastin fibers, which gives strength and elasticity to the connective tissue. The effectiveness of silicon in the formation of connective and bone tissue is evidenced by its role in the adaptive response after a bone fracture or ligament rupture, when the concentration of silicon in injured tissues increases by 50-200 times with a simultaneous decrease in blood by 4 times. There is also a decrease in the mass of cartilage tissue, loss of bone elasticity, increased fragility of the nails and hair due to micronutrient deficiency [9,10].

Moreover, the bound silicon is part of protein complexes. The need of the human body for silicon is 30 mg per day [11], it increases for athletes.

The absorption of silicon by the human body depends on the form in which it enters the body with food. In particular, silicic acids are well ingested, quickly absorbed, having entered the blood they are transported to organs and tissues, while excess silicon is eliminated through the urogenital system and its concentration in biological fluids remains within the physiological standard [11].

The share of domestic drinks for athletes in the consumer market is only 10-15% of the total amount, while the range of Russian drinks includes maximum 10 brands.

In view of the foregoing, the goal of our research is the development and implementation of a high-tech formulation and production scheme for a drink for athletes based on the ARDVI mineral water enriched with natural metasilicic acid and AABCC.

III. Research Methodology

Studies of the quality of the drink were carried out according to standard techniques. The study of the quality and safety of ARDVI water used for the production of the drink was carried out at the Federal Budget Institution of Science "Ekaterinburg Medical and Scientific Center for Prevention and Health Protection of Industrial Workers", Federal State-Funded Healthcare Institution "Center for Hygiene and Epidemiology in the Chelyabinsk Region", Federal State Funded Research Institution "All-Russia Scientific Research Institute on Brewing, Beverage and Wine Industry" for compliance with the requirements of GOST R 54316-2001 "Natural Mineral Drinking Water. General Technical Conditions", TR TS 021/2011 Technical Regulations of the Customs Union "Concerning the Safety of Food Products", Recommended Practices of the Ministry of Health of the Russian Federation No. 2000/34, SanPiN 2.6.1.2523-09 "Regulations for Radiation Safety" and TU 9185-004-37881001-12. Water samples were taken in accordance with GOST 31861 "Water. General Requirements for Sampling".

IV. Results of Experimental Researches

Today, the engine of new industrialization is innovative activities, which are based on the processing of raw materials and manufacture of products, including food, using high technologies. The development of a high-tech drink formulation included the use of the following raw materials meeting the requirements of TR TS 021/2011 "Concerning the Food Safety", TR TS 029/2012 "Safety Requirements for Food Additives, Flavors and Technological Aids", allowed for use in the production of food by Rospotrebnadzor (Federal Service for Supervision of Consumer Rights Protection and Human Well-Being) and accompanied by documents

confirming their quality: natural mineral drinking water "ARDVI" TU 9185-004-37881001-12; fructose K.S. 1.7; complex nutritional supplement - Aspartame (E951); acidity regulator - citric acid (E330; amino acids (valine, isoleucine, leucine); sodium citrate, Kiwi flavour FM006116; sodium benzoate (E211) and potassium sorbate (E202).

According to the innovative formulation, we introduced amino acids with branched carbon chains into the composition of the developed drink. It is known that the need of the human body in AABCC is up to 35-40% of the total need for essential amino acids. It is advisable to consider the mechanism of action of these amino acids. The daily value of leucine per person is 1.1-1.2 g. In the case of oral administration, leucine is well absorbed, penetrates the blood-brain barrier and has a particularly pronounced ability to stimulate protein biosynthesis, cellular metabolism, cell growth, forming the structures of the protein molecule (folding). It should be noted that one of the main functions of AABCC is the energy function for skeletal muscles. AABCC are transaminated in the muscles into the corresponding keto acids, which are then utilized in gluconeogenesis reactions in the liver. During moderate physical activity, the pool of AABCC remains at a constant level, despite the activation of protein breakdown processes [12,13]. However, during heavy and prolonged physical activity, the oxidation of AABCC in skeletal muscles often exceeds their release from muscle proteins. As a result, the concentration of AABCC in blood decreases, which contributes to the transport of tryptophan in the central nervous system and increases the formation of serotonin in the brain [14-16]. One of the consequences of this effect may be the development of fatigue of central origin. In this regard, it is interesting that the use of AABCC-based drinks by athletes allows to recover from heavy physical activities.

The developed high-tech scheme for the production of the drink includes the following steps: acceptance of raw materials; water preparation (natural mineral drinking water "ARDVI"); sequential preparation and introduction of components of the blending syrup, preparation of the drink; filling, capping, quality inspection, labeling, packaging and transfer of finished products to the warehouse; storage and transportation of finished products.

Acceptance of raw materials is carried out in accordance with the approved requirements F.7.1-01-13 "Requirements for Raw Materials when Planning Purchases"; F.8.2-01.06 "List of Raw Materials Subject to Incoming Inspection and Testing"; F.7.1-01-07 "Requirements to the Conditions and Periods of Storage of Raw Materials". Preparation of water for the production of the developed drink is carried out in accordance with the Technological Instruction for the Production of Drinking and Mineral Carbonated and Non-carbonated Water Packaged in PET Bottles of 0.5-1.5 dm^3 (TI 9185-37881001-13-2017) and the Technological Instruction for the Treatment of Water for the Production of Beer and Non-alcoholic Beverages (TI 10-5031536-73-90), as approved by the Research and Manufacturing Association for Drinks and Mineral water on December 20, 1990.

The blending syrup (for the drink) is prepared by adding (subject to constant mixing) certain components provided by the formulation of a particular drink in the following sequence: part of water (1/5), natural mineral drinking water "ARDVI"; water solution of amino acids (glycine, valine, isoleucine, leucine), sweetener water solution; citric acid water solution, flavouring water solution; preservative water solution; natural mineral drinking water "ARDVI" to the estimated volume. Before filling, the prepared blending syrup is allowed to stand at least half an hour to achieve stability by organoleptic and physical and chemical parameters. Immediately before filling, a model drink is prepared, for which the blending syrup intended for filling and the prepared water are brought to a temperature of 20°C and mixed in a ratio that ensures the formulating, organoleptic, physical and chemical parameters and the nutritional value of the drink. Then the model drink is mixed, its organoleptic parameters (appearance, taste, colour and flavour) are examined and titrated acidity is tested for compliance with the formulating values. The obtained value of the acidity of the drink is a reference value and is used to start the filling line.

The drink is prepared by means of a synchronous and mixing unit from a blending syrup and prepared water at the ratio of 1:5 (another dilution is possible). The finished drink is filled into bottles made of polymeric materials such as PET. The batching of the drink is performed by volume.

Bottle closing is carried out in accordance with a given program. Consumer packaging is sealed using means of closing approved by Rospotrebnadzor of Russia for contact with this type of product. Closing is carried out in accordance with GOST R 52844-2007, GOST 8.579-2002.

After filling and closing, bottles undergo a drying procedure in order to remove the residual drink from their surface with the subsequent blowing off. Bottles filled with the drink are labeled. The finished drink is examined for organoleptic, physical and chemical and microbiological parameters at the beginning of the filling and then during the filling. The frequency of control may vary depending on the performance of the filling line.

From the standpoint of research of new industrialization, the greatest interest lies in the increase in the competitiveness of new products. One of the indicators of the competitiveness of new products, including the developed drink for athletes, is their qualitative characteristics.

Organoleptic parameters of the quality of the developed drink are presented in Table 1.

TABLE 1. ORGANOLEPTIC PARAMETERS OF THE DRINK FOR ATHLETES BASED ON ARDVI MINERAL WATER ENRICHED WITH AABCC

Parameter	**Characteristics**	
	Post production	**After 14 months of storage**
Appearance	Sediment- and contaminant-free transparent liquid. A slight natural sediment of mineral salts is allowed.	Sediment- and contaminant-free transparent liquid. A slight natural sediment of mineral salts is allowed.
Colour	Colourless	Colourless
Taste	Fruit	Fruit
Flavour	Kiwi	Kiwi

The data of Table 1 show that after 14 months of storage the organoleptic parameters of the developed drink are at a high level and have not changed since manufacture.

Table 2 represents the physical and chemical parameters and the content of biologically active components in the drink for athletes based on ARDVI mineral water enriched with AABCC

TABLE 2. PHYSICAL AND CHEMICAL PARAMETERS AND CONTENT OF BIOLOGICALLY ACTIVE COMPONENTS IN THE DRINK FOR ATHLETES BASED ON ARDVI MINERAL WATER ENRICHED WITH AABCC

Parameter	**Characteristics**	
	Post production	**After 14 months of storage**
Major ionic composition, mg/l: HCO_3^-	384	382
SO_4^{2-}	87	83
Cl^-	114	117
Ca^{2+}	92	92
Mg^{2+}	81	78
$(Na+K)^+$	76	79
Mineralization, g/ dm^3	0.8	0.8
Specific component H_2SiO_3, mg/dm^3	53	53
Amino acids		
Glycine,	0.1	0.1
Valine,	2.1	2.1
Isoleucine,	1.3	1.3
Leucine, g/100 ml	0.3	0.3
Acidity, cm^3 of sodium hydroxide solution with a concentration of 1.0 mol / dm^3 per 100 cm^3	2.0±0.3	2,0±0,3

The data of Table 2 show that after 14 months the major ionic composition, the amount of the biologically active component of the drink - meta-silicic acid and the content of AABCC do not change significantly. Consumption of 200 ml of the drink provides from 72 to 93% of the bodily need for athletes in silicon and up to 95% in AABCC.

It has been established that all microbiological parameters of the developed drink after production and storage for 14 months complied with the requirements of the Technical Regulations of the Customs Union TR TS 21/2011 "Concerning the Food Safety" (Annex 1, Appendix 2, Section 1.7).

Based on the studies conducted, the following standard parameters for the quality of the drink, the period and mode of its storage have been established: 12 months at a storage temperature of 0°C to 25°C and a relative humidity of max. 85%.

TABLE 3. STANDARD PARAMETERS FOR THE QUALITY OF THE DRINK FOR ATHLETES BASED ON ARDVI MINERAL WATER ENRICHED WITH AABCC

Parameter	**Characteristics**
	Post production
Appearance	Sediment- and contaminant-free transparent liquid. A slight natural sediment of mineral salts is allowed.
Colour	Colourless
Taste	Fruit
Flavour	Kiwi
Major ionic composition, mg/l: HCO_3^-	300-500
SO_4^{2-}	70-90
Cl^-	100-140
Ca^{2+}	70-120
Mg^{2+}	60-100
$(Na+K)^+$	60-90
Mineralization, g/ dm^3	0.6-1.2
Specific component H_2SiO_3, mg/dm^3	40-60
Amino acids Glycine,	0.05-2.0
Valine,	1.5-2.5
Isoleucine,	1.0-2.0
Leucine, g/100 ml	0.1-0.5
Acidity, cm^3 of sodium hydroxide solution with a concentration of 1.0 mol / dm^3 per 100 cm^3	Less than 3

V. CONCLUSION

It may be considered that one of the growth points of the state's economy during the period of new industrialization is pharmaceutical production with elements of food products based on the release of new dosage forms, in particular, drinks with biological active substances based on high technologies for certain population groups, in particular, for athletes and for individuals with a high level of physical activity. This is facilitated by the activation of innovative activities of advanced food industrial enterprises towards the introduction of research and fundamental developments, through the integration of science into production. In addition, the economic feasibility of innovative activities of an enterprise is

determined by the creation of a high-tech product transformed into a competitive product that is in demand in the consumer market. As a result of technologization of scientific knowledge, the formulation and technology of a drink for athletes has been developed. The biologically active components in the developed drink are silicon and amino acids with branched carbon chains. As a result of studies, it was established that after 14 months of storage of the drink, organoleptic, microbiological, physical and chemical parameters and the content of biologically active substances did not change significantly. It has been established that the reference intake (200 ml of the drink) provides from 72 to 93% of the bodily need for athletes in silicon and up to 95% in AABCC. Based on the studies conducted, the following standard parameters for the quality of the drink, the period and mode of its storage have been established: 12 months at a storage temperature of 0°C to 25°C and a relative humidity of max. 85%. According to the results of the studies it is possible to state the cooperation of enterprises with science by means of technological modernization, which is confirmed by the production of new popular competitive products as an example of neo-industrialization of the industrial sector of the Russian economy in the sixth technological paradigm.

References

[1] Polterovich V. (2006) Evolutionary Theory of Economic Policy, *Issues of Economics*, №7, pp. 4-23.
[2] Klinov V.G. (2016) Causes and consequences of the modification of the large cycle of the world economy, *Crises and forecasts in the light of the theory of long waves*, Volgograd: Teacher, pp.89-108.
[3] Ryazanov V.T. (2017) A New Industrial and Technotronic Society: the Future is in Question, *Economic Revival of Russia*, №2, pp. 47-54.
[4] Bodrunov S.D. (2016) Concerning the evolution of the economic and social structure of the industrial society of the new generation, *Economic Revival of Russia*, №3 (49). pp. 5-18.
[5] Gerasimenko N.F. (2017) Methodological Aspects of Complete, Safe Nutrition: Importance in Maintaining Health and Efficiency, *Human. Sport. Medicine*, №1. Vol. 17, pp. 79 -86.
[6] Tolmachev O.A., Tolmachev V.O., Tikhonov S.L., Tikhonova N.V. (2017) Influence of Ardvi silicon-containing water on the regeneration of soft tissues and long-term muscle soreness left, *Human. Sport. Medicine.*, №S, Vol. 17, pp. 73 -84.
[7] Chen J. (2000) Vitamins: Effect of Exercise on Requirements, *Nutrition in Sport, Blackwell Science Ltd.*, pp. 281-291.
[8] Clarkson P.M. (2000) Trace Minerals, *Blackwell Science Ltd.*, pp. 339-355.
[9] Klimova E.V. (2011) Analysis of Bioavailability of Silicon in Food Products (Belgium), *Environmental Safety*, № 2, pp. 532.
[10] Klimova E.V. (2010) Concerning the increased losses of macro-and microelements in sports and the feasibility of compensating with biologically active additives, *Food and Processing Industry*, № 1, p. 197.
[11] Vapirov V.V, Feoktistov V.M., Venskovich A.A., Vdpirovd N.V. (2017) Concerning the behavior of silicon in nature and its biological role, *Scientific Notes of Petrozavodsk State University. Series: Social and Human Sciences*, № 2, pp. 95-102.
[12] Sheybak V.M. (2014) Leucine, isoleucine, valine: biochemical basis for the development of new drugs: monograph, *Grodno: Grodno State Medical University*, p. 244.
[13] Blomstrand E., Hassmen P. (1997) Influence of ingesting a solution of branched-chain amino acids on perceived exertion during exercise, *Acta. Physiol. Scand*, Vol. 159. pp. 41–49
[14] Smriga M., Kameishi M., Tanaka T. (2002) Preference for a solution of branched-chain amino acids plus glutamine and arginine correlates with free running activity in rat., *Nutr Neurosci*, Vol. 5, pp. 189–199.
[15] Stipanuk M.H. (2007) Leucine and protein synthesis: mTOR and beyond, *Nutr Rev*., Vol. 65, pp. 122–129.
[16] She P., Olson K.C., Kadota Y. (2013) Leucine and protein metabolism in obese zucker rats, *PLoS One*, Vol.8, № 3, P. 59443.
[17] Yalunina E.N. (2018) Development of the Bakery Products Assortment Correspond with Consumer Preferences, *Food Industry*, T. 3., № 2, pp. 55–59. DOI: 10.29141/2500-1922-2018-3-2-9.