Production and use of basic technological facilities for BAT in the food and processing industries of agribusiness

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Abstract. The best available technologies (BAT) for the food and processing industry are presented. They are included in the Russian information and technical reference books (ITR-43, ITR-44, ITR-45). The state of production and applying the facilities for BAT in following areas specified in references: slaughter and primary processing of livestock; milk processing; production of meat products, sugar and vegetable oils; processing and preserving of fruits and vegetables. The level of technical import dependence in these areas is presented.

1. Introduction

The principle of the best available technologies (BAT) is introduced into international practice by the EU Directive on integrated pollution prevention and control 96/61/EU [1]. In Russia, work in this direction began in 2014, when the Government of the Russian Federation approved a set of measures aimed at abandoning the use of obsolete and inefficient technologies, switching to BAT principles and introducing modern technologies [2].

The first step in the transition of domestic industry to the BAT principles was the creation of industry-specific information and technical reference books on BAT. Between 2014 and 2017, 51 handbooks were prepared and published for all industrial sectors, three of which concern food and processing industries. [3,4].

The meaning of the transition to the BAT principles is the symbiosis of two processes. First is creating additional incentives for the development of domestic industry, which means increasing its competitiveness. Second one is reducing the negative impact on nature.

2. Methods

The study was carried out using theoretical methods of analyzing and generalizing the information on the production of equipment with the required characteristics from available sources. Functional characteristics of the facilities were studied using the structural method. The obtained results were processed and presented in the form of tables with the allocation of equipment characteristics that are essential for the study. Based on the data obtained, conclusions were drawn about the facilitization level that meets the requirements of BAT, various branches of food and processing industries.
3. Results and Discussion

By analyzing information sources, it can be concluded that the significant part of the Russian market of facilities for slaughtering livestock and processing by-products (ITR-43) [5], which uses the best available technologies, is held by foreign companies: “Banss”, “Freund”, “HubertHaasGmbh”, “Abele” (Germany), “Voran” (Austria), “Jarvis” (USA), “StorkMPS” (Netherlands), “Rovani”, “Lorini”, “Ollari&Conti” (Italy), “Intermik” (Poland), Brestmash OJSC (Belarus), Poltuvamash OJSC (Ukraine). The share of domestic facilities, according to experts, does not exceed 10-12%. There are few companies engaged in the development and manufacture of facilities for slaughter and primary processing of livestock, such as the following: OOO “MM PRIS”, OOO NPP “Iniciativa”, OOO PP “Pil’ninskij zavod “Agropromservis”, OOO “KB Runda”, OOO “Askond-Prom”. According to processors, it is not yet competitive with Western producers and does not meet the needs of modern meat processing enterprises. Some detailed examples are presented in table 1.

Table 1. Examples of equipment for BAT (ITR-43).

| Technological process | Characteristics of facilities, name, manufacturer, technology number in the directory | Availability of domestic models |
|------------------------|-------------------------------------------------------------------------------------|---------------------------------|
| Stunning animals       | Boxes for stunning (companies “Banss”, “Voran”, “Brestmash”) (BAT 1.4, BAT 2.4)      | PM-FBO OOO “MM PRIS”, V2-FE’K-U OOO PP “Pil’ninskij zavod “Agropromservis” No |
|                        | A humane way to stun cattle is the use of pneumatic pistols (BAT 1.4). There are models without penetration into the skull of an animal, for example, USSS-2 of the American company “Jarvis” Carbon dioxide stunning (BAT 2.4) ensures the absence of convulsive contractions of muscles, spinal fractures, and hemorrhages in the tissues and organs of the animal (“Banss” company installation) |
| Blood recovery         | High-performance blood recovery systems with a carousel configuration, which consist of individual modules for servicing each individual carcass, are suitable for the implementation of BAT 2.6 (“Anitec” company) As a result of using the electro-stimulating devices, an additional discharge of 1 to 2 kg of blood from the carcass is provided, the time of blood discharge is decreased, and most importantly, the pH level of meat is reduced and its properties are improved (BAT 1.7). |
|                        | Livestock bleeding stimulator SKS-100 OOO PP “Pil’ninskij zavod “Agropromservis” No |
| Skinning               | Effective skinning that prevents incisions, cuts or holes, made using skinning knife by "Jarvis" company for cattle and small cattle (BAT 1.8) |
| Primary treatment of carcass | For the implementation of BAT 1.10, 2.10, 3.7, 3.8 circular saws, band saws, pincers for separating limbs, a cutter for opening the sternum of small cattle made by “Jarvis” (USA), as well as a Chine-Bone-Cutter (CBC) device for cutting the ridge from pork half carcasses by the “Freund” company, where bone dust and material losses are minimized. |
|                        | OOO PP “Pil’ninskij zavod “Agropromservis” No |
| Unhairing              | Thanks to the spraying system of water, there is minimal contamination of carcass surfaces by bacteria and insignificant fresh water consumption (BAT 2.8), “Banss” company unhairing machines |
| Treatment of mucose and woolly offals Slaughter and | Batch machines with predominant implementation of the centrifugal-rotational operation principle (centrifuges and drums) (“Ollari&Conti”, “JWE Baumann”) |
|                        | OOO PP “Pil’ninskij zavod “Agropromservis” No |
Among the facilities for **processing secondary raw materials**, separators for separating the blood of farm animals into plasma and uniform elements can be distinguished (BAT 8.1). Such separators can be both foreign ("Westfalia", "AlfaLaval") and domestic production (AO "Plava").

The facilities used in BAT 9.2 for the processing of fat (the line for the fat extraction, the machines for fat extraction, the autoclave for the pork fat extraction, the machine for the fat extraction from bone) is produced by OAO “Poltavamash” (Ukraine). The following facilities for the processing of non-food waste are also produced here: a facility complex for the production of meat and bone meal K7-FML (capacity 100 kg/h), designed for the processing of non-food waste and condemned products from slaughter of cattle and the production of meat and bone meal and technical fat in workshops of low power; power bone chopper, horizontal-vacuum boiler, screw press and crusher for greaves (BAT 12.2, 12.8).

Domestic facilities for BAT of waste processing (BAT 11.1) are continuous production lines of feed flour and fat Y8-FOB-MA05P, Y8FOB-MA06P, Y8-FOB-M (manufacturer OOO “Askond-Prom”). The absence of formation of foul-smelling gases during processing (only juice vapors) and the usage of recycled water are the advantages.

In our opinion, the facility for BAT 12.2 is a line for processing waste by extrusion. The extrusion process takes no more than 30 seconds. During this time, the raw material manages to go through several stages of processing: thermal, sterilization, disinfection. There are completely no by-products created during processing, as well as harmful emissions, effluents and harmful odors that accompany traditional processing in waste heat boilers, cremators, incinerators, etc. The line requires only electricity. Gas, steam, water are not needed. The lines supplied by the Russian company “Ekorm” are already operated by various enterprises in Russia, Belarus, Kazakhstan, Moldova, Serbia, Georgia, Armenia, and Ukraine.

A number of BAT ITR 43 (13.1-13.13) in the handbook have environmentalistic nature and cover wastewater treatment issues. From 70 to 90% of the consumed water in meat processing plants is formed by wastewater contaminated during production, which has a high load of organic pollutants.

The cleaning equipment that can be recommended for the implementation of BAT includes grease traps with automatic collection and removal of grease sludge and residue (BAT 13.4), electroflotation devices (BAT 13.6), and a biological aerobic reactor (BAT 13.7). Russian enterprises have mastered the production of these facilities, which is not inferior to foreign analogues. The following Russian companies offer equipment and engineering in the field of industrial wastewater treatment: OOO “AGK E’kologiya”, OOO “E’koton”, OOO “Promy’shlennaya vodochistka”, NPO “E’koVodInzhiniring”, NPO “E’ko-sistema”, NPP “Zavod Akvakrat” and others.

“E’koton” produces flotators of various standard sizes with a productivity from 5 to 100 m³/h. [eight]. Biological wastewater treatment plants using a membrane bioreactor (MBR) are the most advanced wastewater treatment plants that achieve the highest levels of treatment, as well as the smallest in size and occupied area. Productivity is from 200 to 50,000 m³/day. [6-15].

In 2017, the ITR 45 industry directory “Proizvodstvo napitkov, moloka i molochnoy produktsii” was also approved. It includes 33 of the best available technologies for the **production of dairy products**.
When analyzing the technique of the plants, it turned out that there were no domestic facilities for the implementation of BAT 6, 15, 18, 19, 21, 31, 33 of ITR 45.

The introduction of BAT 4 is based on the use of plate pasteurizing-cooling plants with a regeneration coefficient of 85-90%, such equipment is available of both imported and domestic production.

The implementation of BAT 5 requires introducing computer technologies at the milk processing enterprise in order to monitor and control technological operations and CIP-washing of equipment. Such software is offered by domestic manufacturers for the equipment they sell (AO “Zavod Molmash”; OOO “Sel’mash “Molochny’e Mashiny’ Russkix”; OOO “Protemol”), but often this equipment is manufactured on the basis of imported components.

There are only imported heat exchangers with hibernation mode for BAT 6.

Facilities for BAT 7, which consists in detecting the transition between the product and the aqueous phases using sensors, for example, are produced by domestic companies NPK “Teko”, ZAO “Sensor”.

Capacitive facilities for BAT 8 is presented on the domestic market by many manufacturers, such as OMG AO “Zavod Molmash”; VS OAO “Oskon”; OXR, OMV, OMG GK “Zavod molochny’x mashin i emkostnogo oborudovaniya”; stainless storage tanks, stainless tanks by “Grand”; OXR, OSV OOO “StilProm”.

Homogenizers for the separate homogenization of cream during the production of pasteurized milk and fermented milk drinks (BAT 9) are manufactured both in the Russian Federation and abroad.

There are domestic facilities by the companies of OAO “Zavod Start”; OOO “Protemol”; OOO “Sel’mash “Molochny’e mashiny’ Russkix”, for the manufacture of cottage cheese on flow mechanized and automated lines (BAT 11). Imported lines are also quite widely represented.

BAT 12, which is the packaging of oil and spreads produced using the converting high-fat cream method to the consumer pack directly upon its production (direct packaging), can be conducted using the facilities of OOO “Protemol” and AO “Zavod Molmash”.

Vacuum packers for maturing into polymer films, which are used to pack cheeses (NDT 15), are represented by imported facilities. Russian companies ZAO “TAURAS-FENIKS”, “Vakuum upakovochny’e sistemy’” are the suppliers.

BAT 17 is implemented using plate devices, tanks and pumps, provided with domestic facilities. A similar set of equipment is needed for BAT 32, which consists in the use of secondary heat during pasteurization during the production of ice cream.

There are only imported vacuum-evaporator installation samples for condensing milk raw materials in multi-case vacuum evaporators (BAT 18) and for mechanical compression of steam in vacuum evaporators, which are used for implementing the BAT 19.

When producing dry dairy products by heating the concentrate before serving for drying, it is possible to increase the productivity of the dryer by 1% for every 5 °C (BAT 20). Moreover, the energy consumption for drying 1 kg of skim milk can be reduced by 15% (in two-stage installations), and by 40% (in three-stage ones) by using multi-stage drying (BAT 21). In order to carry out these technological processes, modernization of dryers is required, which is performed using imported components or on the basis of imported facilities.

NDT 22 can be provided with domestic equipment; bag filters of modern design are produced by OOO “E’koFil’tr”; SFR Samarskij zavod “Strommashina”.

Actual energy savings when using a recuperator in BAT 23 are 18%, AO “Zavod Molmash”, OOO “Slavutich” and OAO “Oskon” have such recovery systems.

Water circulating systems with full use of condensate (BAT 25) will require the use of tanks for warm water; such capacitive equipment is widely represented on the domestic market.

The collection and use of the first wash water from vacuum evaporators for fodder products, according to BAT 26, will require concentration costs with the use of proper facilities, in particular vacuum-evaporator installations.

The use of membrane methods is also mainly carried out using imported facilities, and imported components are used in existing domestic plants. This equipment is necessary for the following
technologies: brine cleaning at cheese-making plants, which ensures the implementation of BAT 16; whey processing (BAT 27); production of cottage cheese and soft cheeses on production lines using ultrafiltration to separate whey from a coagulum (BAT 28); production of cottage cheese, soft cheeses and semi-hard cheeses on production lines with preliminary ultrafiltration of milk (BAT 29); pre-concentration of milk raw materials using reverse osmosis and nanofiltration (BAT 30).

Packaging facilities for BAT 31 is represented only by imported models. There is completely no domestic facilities (continuous freezer) used in BAT 33.

There is no equipment for the first three BAT, because they are related to improving management at a milk processing enterprise. The introduction of BAT 10, 13, 14 is based on a change in the technological process that is independent of equipment [16-22].

Let us consider BAT ITR 44 [20] and facilities for the production of meat used in their processes. The reference book, unfortunately, includes mainly environmental technologies for meat processing plants. Equipment of domestic production can be selected for these technologies.

Technological facilities for the production of meat products are mainly imported. It is difficult to use exact figures, however, according to various estimates, Russian meat processing enterprises are currently 80–95% equipped with imported facilities.

For example, equipment for BAT 1, which is continuous tunnel type sterilizers providing the secondary use of steam and water, is produced by the Hungarian company “HUNISTER Innova SterKft”.

Indeed, the major part of meat processing equipment is supplied to Russia from Europe. The leading positions are occupied by manufacturers in Germany, Austria, Holland, Italy, Spain, whose equipment is not only reliable and has long service life, but also has a high service level. In particular, facilities of the German companies “Banss”, “Meatech, Kainz”, the Dutch company “MPS”, the Danish “Haarslev”, and the Austrian “Schaller” are used at the production spaces of the MPZ “Agro-Belogor’е”.

Almost everything comes from Europe. Starting from primary processing (slaughter, boning, butchering) and to cutting and packaging of finished products, which is complete sausage production including minced meat production, stuffing, portioning, clipping, heat treatment, etc.

Chinese manufacturers of facilities for the food industry and specifically for meat processing began to enter the Russian market 7–8 years ago. Their presence in Russia was minimal back then and now it has increased. Perhaps, the Chinese equipment is slightly inferior to European models, but this is fully compensated by a more attractive price. Packaging equipment and sausage syringes are mainly bought in China.

BAT for the oil and fat production, which are presented in ITR 44, are also of an environmental nature, in particular for wastewater and air treatment (BAT 1, BAT 2, BAT 3). Equipment for these technologies is manufactured by Russian companies.

BAT 4 involves the use of physical refining with simultaneous deodorization of vegetable oils, instead of chemical refining technology for certain types of oils. The technology is distinguished by lower production costs, a simple process without the use of chemicals, acceleration of the process, and the absence of emissions. Existing equipment may be used for implementation of the technology.

The equipment for the rest of BAT is produced abroad and mainly supplied from Europe. For example, the Norwegian company “Norsk Gidro” produces compact stations for obtaining hydrogen using water electrolysis. They allow excluding the formation of wastewater containing electrolyte (potassium hydroxide), all alkaline effluents are returned to the process.

The main role in enzymatic reprotect technology is played by enzymes. So far they are also produced only abroad, the leader in this area is the Danish company “Novozymes A/S”.

It should be noted that this situation concerns not only BAT facilities. Almost all the facilities operated at large oil extraction plants (OEP) are of foreign production. For example, facilities for the recently opened Sorochinsky OEP was supplied from England, Belgium, Germany, Ukraine, and China.
An important sector of the food and processing industry in terms of BAT is the processing of fruits and vegetables. A list of the best available technologies for this industry was included in ITR 44.

Summarizing the available information, it can be concluded that innovation and resource saving in BAT for fruit and vegetable processing can be achieved using both imported and domestic facilities for BAT 1 and 4. But when comparing technical characteristics, Russian facilities generally inferior to imported models. In order to effectively use it, the modernization is required.

For BAT 2 and 3, continuous belt blanchers and sterilizers of continuous action (tunnel type) are not produced by domestic enterprises. Domestic companies offering such equipment are suppliers, or use imported components for assembly. Existing domestic CIP-washers for BAT 5 generally also include imported components.

A lot of attention in ITR 44 is paid to BAT and facilities for the sugar industry. There are no domestic facilities for the implementation of BAT 1, 2, 5. Effective import phase-out requires the release of presses for the deep pulp squeezing; saturators, providing multiple circulation of the juice, the dispersion of gas in the juice and pulp dryers using steam.

The implementation of BAT 3 requires using the scrubber in the technological process. Such facility is offered by domestic manufacturers, for example, OAO “Pervomajskximmash”.

The introduction of BAT 4 is based on the use of chamber filter presses, such equipment is available both of imported and domestic production.

BAT 6 was not considered because it is implemented on the basis of using the certain directed microorganisms that are not classified as equipment [20-23].

4. Conclusions

The conducted analysis showed that a significant share (about 90%) in the Russian facility market implemented in BAT for slaughtering livestock and processing by-products, is held by foreign companies, in particular Germany, Austria, USA, Netherlands, Italy, Belarus and Ukraine. In order to reduce the import dependence level, state support is necessary for the development and production of domestic innovative facilities for the meat industry, especially in the slaughter sector, which will provide the necessary parameters that meet the requirements of BAT.

In particular, it is necessary to create domestic production of modern pneumatic and gas stunning devices, automated blood collection systems, skinning knives, various modern cutting tools, cutters, mites (including robotic ones), condensation scalding tunnels and shale furnaces for pig carcasses, vacuum steam carcass cleaning systems, automated intestinal processing lines, fat and non-food waste processing machines. Particular attention should be paid to the development and production of BAT equipment in the field of slaughter and primary processing of poultry, negative dynamics can be traced in this sector.

In order to provide BAT in the milk processing industry using the equipment, as well as the effective development of milk processing industries and obtaining the competitive products for import substitution, first of all, it is necessary to produce heat exchangers with hibernation mode; vacuum packaging and shrink machines; membrane equipment; film vacuum evaporators; multistage automated drying plants; aseptic filling and packaging plants; freezers of continuous action. According to experts, about 70% of the facilities of Russian dairy enterprises are now foreign-made.

Russian meat processing enterprises are currently 80–95% equipped with imported facilities, as well as equipment for BAT production of oil and fat products. It should be noted that this situation concerns not only BAT facilities. Almost all facilities operated by large enterprises of the oil and fat industry is manufactured abroad.

For the processing of fruits and vegetables, import phase-out is necessary for almost all BAT.

Among the market segments with a high share of foreign facilities are the sugar industry (81%). For the effective import phase-out of BAT facilities for sugar production, it is necessary to produce presses for the deep pulp pressing; saturators, which provide multiple circulation of the juice, the dispersion of gas in the juice and pulp dryers using steam.
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