

# STATE-OF-THE-ART OF THE INVESTIGATIONS IN THE FIELD OF QUALITY AND SAFETY CONTROL OF MEAT RAW MATERIALS AND MEAT PRODUCTS IN RUSSIA\*

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*Abstract:* Safety and quality of food products, including meat products, is an urgent problem now and will continue to be such in the near future.

Due to this fact, many countries developed novel systems for ensuring food safety and quality. Russia has developed "Complex system of safety and quality control of foods" that is based on the utilisation of: hurdle technologies, HACCP system, prediction microbiology, system of complex continuous monitoring of technological flow including the system of distribution of transport flows and the system of production management.

The All-Russian Meat research Institute (VNIIMP), in the last couple of years performs more complete and reliable safety and quality controls of meat within the complex system. It developed new standards for detection and identification of *L. monocytogenes*, investigated the possibilities of utilisation of natural spices mixtures that lowers the danger of occurrence of *L. monocytogenes* in meat products; defined new antioxidants; introduced new technological procedures for increasing the shelf-life of packaged meat and meat products; defined critical control points for HACCP application in slaughterlines and in meat processing facilities; defined and introduced into practice the system of voluntary HACCP-meat certification in meat industry; the Institute conducts Monitoring programme of toxic substances in meat and meat products; it developed and applied histological method of product components identification; applied electronic nose system (VOC meter) for determination of freshness and meat species; developed the production of kits and primers for PCR methods.

Research and development programmes ensure that meat production and control systems are maintained in accordance with contemporary achievements in science and needs for efficient consumers protection.

**Key words:** safety, quality, methods, investigations, freshness, meat species

## Savremena ispitivanja na polju kvaliteta i kontrole bezbednosti mesnih sirovina i proizvoda od mesa u Rusiji

*Sadržaj:* Bezbednost i kvalitet hrane, uključujući i proizvode od mesa, je sada, veoma aktuelan problem, a očekuje se da će tako biti i u bliskoj budućnosti.

Zbog toga su mnoge zemlje, ili njihove grupacije, razradile nove sisteme za osiguranje bezbednosti i traženog kvaliteta hrane. U Rusiji je razrađen "Kompleksan sistem za kontrolu bezbednosti i traženog kvaliteta hrane", koji je baziran na korišćenju: tehnologije prepreka, HACCP-a, mikrobioloških predviđanja, kontinuiranog monitoringa tehnološkog procesa, uključujući transport, distribuciju i načine upravljanja proizvodnjom.

Sve-ruski naučno-istraživački institut industrije mesa (VNIIMP) poslednjih godina, radi potpunije kontrole i osiguranja pouzdanije bezbednosti i kvaliteta mesa, u okviru kompletnog sistema, izradio je nove standarde za detekciju i identifikaciju *L. monocytogenes*, izučio mogućnost korišćenja smeša prirodnih začina koje smanjuju opasnost od pojave ove vrste bakterija u proizvodima od mesa; definisao nove antioksidanse; uveo nove tehnološke postupke za produženje održivosti upakovanog mesa i pojedinih proizvoda od mesa; definisao kontrole kritične tačke za primenu HACCP-a na linijama klanja i prerade mesa; razradio i, u praksu, uveo sistem dobrovoljne „HACCP-meat sertification“ u pogonima industrije mesa; sprovodi monitoring program kontrole toksičnih supstanci u mesu i proizvodima od mesa; razradio, i kroz, monitoring primenio histološki metod identifikacije komponenata sastava proizvoda; za određivanje svežine i vrsta mesa primenio sistem (VOCmeter) elektronskog nosa i za korišćenje PCR-a metoda obezbedio proizvodnju potrebnih kitova i prajmera.

Istraživački i razvojni programi su i dalje usmereni da se sistemi proizvodnje i kontrole mesa i proizvoda od mesa, održavaju u skladu sa aktuelnim dostignućima nauke i potrebama efikasne zaštite potrošača.

**Cljučne reči:** bezbednost, kvalitet, metode, ispitivanje, svežina, vrste mesa

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## Introduction

Safety and quality of food products, including meat products, is an urgent problem now and will continue to be such in the near future (*Lisicin et al.* 1997).

The incidence of foodborne diseases has increased in the world. Integration between countries and globalization of food trade have led to changes in the existing systems of production and distribution of food products. This will create conditions, when both the known and new foodborne diseases can develop (*Lisicin et al.* 2008).

In the Russian Federation the quality and safety requirements for foods are stated in a number of laws: "On quality and safety of foods", "On protection of consumers' rights", "On technical regulation". Their main task is protection of consumers by ensuring high level of food products' safety (*Lisicin and Veselova* 2004).

The world practice shows that safety of foods can be ensured only through the control of production on the scheme "from field to table". It is already recognized that control should be provided on every stage of food chain – from the production of initial raw materials to final treatment, because there can always be situations when potentially dangerous substances for human health can enter to foods (*Lisicin et al.* 1997).

During last decades, the scientists from the V.M. Gorbatov All-Russian Meat research Institute have paid special attention to these problems, connected with harmonization of exothrophic chain - from production of meat products to their marketing (*Lisicin et al.* 1997). We base our work on extension of our knowledge about technological adequacy of meat raw materials, monitoring the production of safe and high quality products, optimization and ecologization of component composition of the product, using food nutrients, meeting the requirements of food quality, safety and dietetics. At the same time we develop new and improve the existing methods for raw materials treatment, ensuring safety and sanitary welfare of final product; we also work on the development of the methods for the determination of quality and safety indicators of meat raw materials and products.

A practical solution to this problem would be a COMPLEX SYSTEM OF SAFETY AND QUALITY CONTROL OF FOODS in Russia, based upon the use of: hurdle technologies, HACCP system, prediction microbiology, system of complex continuous monitoring of technological flows, including the system of distribution of transport flows and the system of production management (*Lisicin et al.* 2008).

Within the frame of this system, scientific investigations in VNIIMP are carried out in all five directions: scientific approaches, methodical and legal basis and the tools for introduction of this system at meat plants. Traceability system of the whole process of raising domestic animals and raw materials technological processing is studied and put into practical use.

No doubt, it is the prevention of different diseases of domestic animals that is the main factor of safety of food products, and the main challenge for sanitary microbiology is detection and monitoring of pathogens posing threat to safety of the product.

Most pathogens, veterinarians fight now with, have been known for a long time. Salmonella, pathogenic staphylococci, botulism agents, Coli group of bacteria have been for a long time associated with foodborne diseases. However, of special concern is the appearance of new pathogenic strains and, frequency, of cases when the known microorganisms can be found in new, non-typical products for them. One can not explain yet why pathogens are capable to spread all over the world very quickly (*Lisicin et al.* 2002).

For example, *Listeria*. Until recently, there was the opinion that mainly the animals catch listeriosis. And, if in the past *Listeria* were found only in some regions, now the cases of detection of pathogenic *Listeria* are registered all over the world, from New Zealand to the USA (*Lisicin et al.* 2008). Listeriosis is a disease, dangerous for humans, because mortality is 30-40% from the number of infected people, and the damage from this infection is much higher than from other infections.

Scientists from VNIIMP, together with workers from 8 research centers of the Academy of Medical Science, have created a national system of safety assurance and control of food products for the presence of the agent of Listeriosis; also the standard GOST P 51921-2002 has been developed - "Food products. Methods of detection and determination of bacteria *L. monocytogenes*" (*Lisicin and Veselova* 2004).

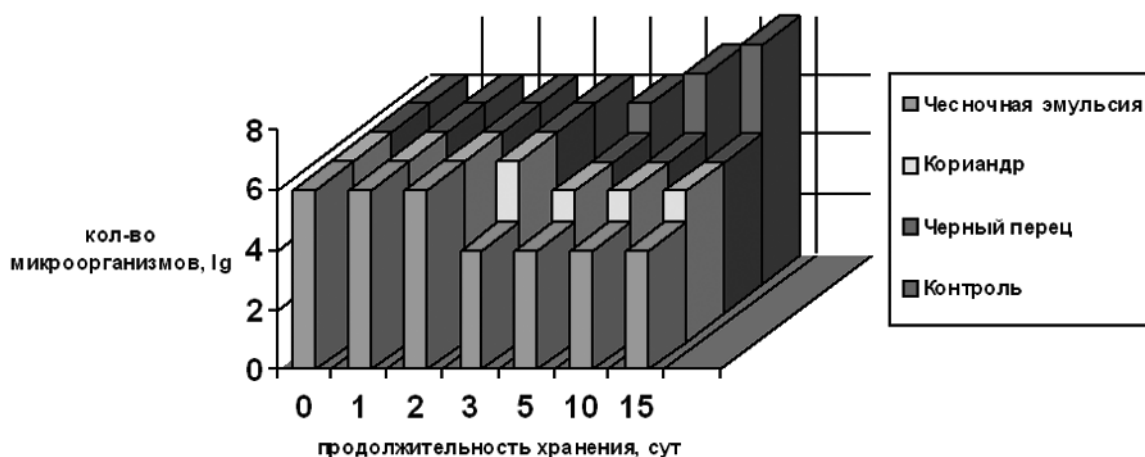
Sanitary stability of the product, as well as its safety is based upon combination of factors, or as they are also called – hurdles. One of such hurdles is biopreservation, whose position among the methods and techniques of quality preservation of products becomes stronger (*Lisicin et al.* 2008).

Spices can also be considered as one of the biopreservatives or non-traditional methods of products treatment to preserve their sanitary welfare. Thus, in the investigation of the curing process and influence of the main recipe mixtures of spices on viability of

Listeria, it was found that such spices, as cardamom, coriander and nutmeg, at 0.005%, reduce viability of Listeria 10-fold, and adding garlic emulsion in the same concentrations reduces viability of Listeria 100-fold (Fig.1).

sausages at high positive temperatures using the additional hurdles, preventing their spoilage (*Lisicin et al.* 2007).

The results of the investigations have shown that, in case of similar level of such hurdles, as initial



**Figure 1.** Dependence of viability of *Listeria monocytogenes* (serovar 1/2b) from added spices  
**Slika 1.** Zavisnost viabilnosti *Listeria monocytogenes* (serovar 1/2b) od dodatih začina

Antioxidant activity of dihydroquercetin (DHQ) in thermally treated and non-treated meat products was also studied, and a possibility of increase of its activity as an antioxidant was proved. The efficient doses of dihydroquercetin were determined for mechanically separated poultry meat, which is subjected to oxidative spoilage to the most extent (*Lisicin et al.* 2008).

The investigations have shown that in the sample with dihydroquercetin, at 0.02% to the mass of the raw materials, hydrolytic and oxidative changes occurred 3-fold slower, as compared to the control group (without DHQ). Study of genotoxicity of dihydroquercetin by the "DNA-comet" method at its dosage of 1.5 and 150 mg/kg, demonstrated its safety.

Comparative evaluation of natural antioxidants, including monomer DHQ, has allowed ranking them by their antioxidant properties as follows: for fat products (on the example of raw fat) – DHQ > tocopherol > rosemary extract > tea catechins; for products with high moisture content (>70%) (on the example of MSPM) – DHQ > rosemary extract > tea catechins > tocopherols.

Based on the study of solubility and stability of DHQ in solutions, a possibility of creation of commercial form of DHQ for meat industry as a solution containing 2-5% DHQ and 2-5% of ascorbic acid was established.

To develop technologies of cooked and smoked sausages, not requiring cold storage, VNIIMP specialists were studying keepability of cooked-smoked

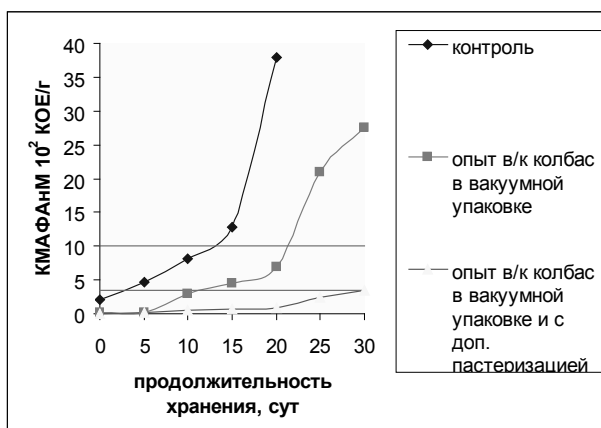
count of microorganisms, sodium nitrite content and pH value, changes in thermal treatment of sausages (reducing the time of smoking and elimination of secondary smoking) to increase the final product yield will lead to changes in the content of salt, moisture and water activity. This will result in reduction of their hurdle effect to the levels that will not ensure stable storage of sausages, even at low positive temperatures (2-6°C).

The studies have shown that the introduction of additional hurdles into technology – vacuum packaging and additional thermal treatment (72-76°C during 15 minutes) – will increase shelf life of cooked-smoked sausages, manufactured according to the proposed recipes, to 25 days at 18-20°C, instead of 3 days (Fig.2).

Further investigations will include the study of the influence of thermal treatment conditions, different doses of food additives with hurdle effect on quality and safety of cooked-smoked sausages in storage at high positive temperatures to increase their shelf life up to 45-50 days.

One of the approaches to the prevention of foodborne diseases and for safety of products is the use of HACCP system, which has been functioning at food plants of EC countries for many years (*Lisicin et al.* 2008).

The investigations carried out at the Institute will allow producers to reveal critical control points in production of different meat products, which should be controlled for removal of risk factors or elimination to minimum a possibility of their



**Figure 2.** Change in the count of microorganisms in the experimental samples of cooked-smoked sausages during storage at 18-20°C

**Slika 2.** Promena broja mikroorganizama u eksperimentalnim uzorcima kuvano-dimljenih kobasica tokom skladištenja na 18-20°C

occurrence and also to compose a list of the most frequent non-conformities at meat plants.

Analysis of production chain for sausage products was carried out, beginning from raw materials supply and finishing with laboratory investigation of final products.

The obtained data suggest that frozen raw materials, supplied in sides, had larger microbial load

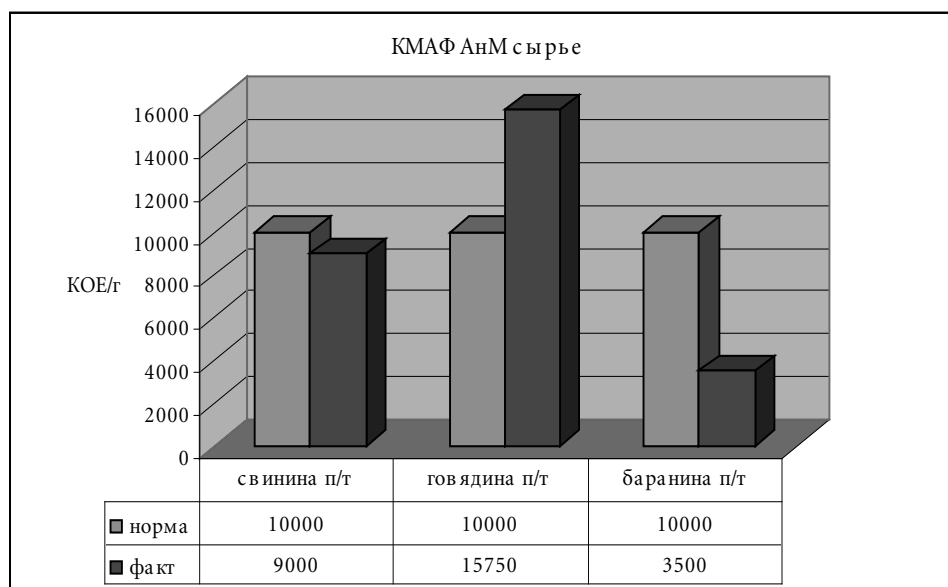
in cartons, which significantly reduced the possibility of additional contamination of the raw materials.

The obtained results show that the first link of the internal traceability - laboratory control of incoming raw materials - is an important component of safety management of foods, because knowledge of the extent of microbial contamination of raw materials allows managing logistics of the warehouse more efficiently and thus helps preventing non-conformities with regards to the biologically dangerous factor at the initial stage of technological process.

Besides, the amount of microbial contamination of the casings, both artificial (polyamide), and natural, were investigated, as well as spices, wash-outs of the hands of workers and equipment.

The results of the investigations have shown that adoption of a system of monitoring and traceability of hazards at the plant will allow a more efficient management of technological process and control safety of produced foods.

At the All-Russian Meat Research Institute the System of voluntary certification HACCP-MEAT has been developed and registered. It provides for the development of the system of safety and quality management at a meat plant as applicable to the specifics of meat industry plants of Russia.



**Figure 3.** Average total plate count in sides

**Slika 3.** Prosečan ukupni broj mikroorganizama u mesu

(Fig. 3) than those in blocks. One can suppose that during transportation and unloading/loading of sides and quarters their surface was not protected from the contact with the environment, while the meat in blocks was first packed in film and then

A Methodical Center has been established and functioning at the Institute, which renders consultancy to meat industry plants with regards to the development, implementation and preparation for certification of quality management system and

products safety assurance on HACCP principles (Lisicin *et al.* 2008).

At present, there are more than 15 certified meat plants in this system: in Noginsk, Obninsk, Tcherepovets, Yoshkar-Ola, Borisov, etc.

Based on the principles of traceability, the scientists of the Institute are developing the system of complex monitoring and control of toxic substances content in meat products. In the North-Caucasus region of RF a data bank is being created with the analysis of toxic substances content in organs and tissues of slaughter animals; dynamics of their accumulation is determined, and critical control points of toxic substances in organs and tissues of farm animals and poultry are indicated. Comparison of data (Table 1) of 2008 with the results of the investigations, carried out in 1986-89 has shown, that content of toxic substances in farm animals during last 20 years has increased on average by 3.5-4 times (Lisicin *et al.* 2002).

Thus, monitoring of composition of cooked sausages “Doctorskaya”, “Molochnaya”, and “Rus-skaya” for 2008 supposedly manufactured according to GOST, was carried out by histological method of identification of meat products composition (Lisicin *et al.* 2008). It demonstrated that the share of plants, whose products contain large amounts of one or several not allowed additives, constituted more than 66.5% of the total number of the monitored plants. The percentage of plants which don't use the additives, not allowed by GOST at all, is only 3,5% (to compare: in 2006 - 24%, in 2007 – 11%).

Use of instrumental methods – multi-sensory system “Electronic nose” - allowed developing the methods for the evaluation of freshness of pork, showing also good prospects for the determination of species of meat on “VOCmeter (Germany), which is intended for conducting quality and quantity evaluation of gas mixtures (Černuha *et al.* 2008). The scientists of the Institute have determined the regi-

**Table 1.** Content of residues of harmful substances in pigs' organisms  
**Tabela 1.** Sadržaj rezidua štetnih supstanci kod svinja

Name	Contents, mg/kg											
	Krasnodar region (the highest values) 1986-1989.				Rostov region Unfavorable zone (2007-2008)				Lipetsk region Unfavorable zone (2007-2008)			
	Pb	Cd	Cu	Zn	Pb	Cd	Cu	Zn	Pb	Cd	Cu	Zn
Muscle tissue	0.02	0.01	0.8	33.8	0.18	0.01	7.1	17.6	0.16	0.03	1.2	6.5
Liver	0.06	0.1	9.2	63.4	0.5	0.079	15.6	50.2	0.17	0.03	3.5	12.5
Heart	0.02	0.01	4.2	21.3	0.46	0.087	18.1	56.4	0.23	0.02	8	29.1
Kidneys	0.11	0.75	3.9	24.3	0.98	0.047	17.5	52.3	0.26	0.045	7.4	33.5

The situation relating to quality control and safety of foods has become more acute with sharply increased import of food products. According to the Federal Customs Service, in the period January-November 2008, the value of import of raw materials and food products to Russia constituted US\$31.9 blns., which is 30.5% more, than in the corresponding period of 2007 (US\$24.4 blns.).

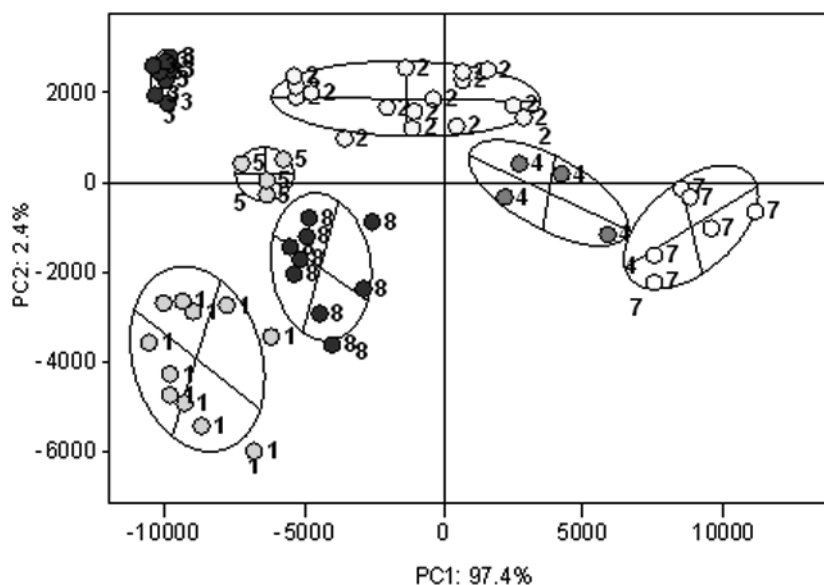
Development of the method of identification and detection of adulteration of raw materials and foods, and also the control over observation of scientifically based recipes and determination of raw materials composition are great challenges in Russia now.

Specialists of the Institute have developed GOST R 51604 “Meat and meat products. Identification of the composition by histological method,” which makes possible identification of animal and plant components in the raw materials used in the manufacture of meat products (Hvilja and Paršenkova 2006).

ons of points in coordinate system of the instrument, characteristic of the samples “fresh”, “doubtfully fresh” and “not fresh”, and of the meat of different animals: beef, pork, chicken meat, turkey, ostrich, deer meat (Fig.4).

The other method, which has good prospects for the determination of species of the tissues of animal and plant origin in the meat raw materials and meat products, is the method of polymerase-chain reaction, which allows revealing the species of meat even in minor quantity, including thermally treated meat products.

Specialists of the Institute have conducted investigations on the determination of nucleotide sequence, based on which synthesis of species specific primers to the fragments of DNA of animal and plant origin (beef, pork, chicken meat, turkey meat and soya) has been accomplished. Study of species composition of meat raw materials and meat products of foreign and domestic origin has shown that



**Figure 4.** Use of multi-sensory system for the determination of meat species: 1 – pork; 2 – beef; 3 – chicken meat; 4- fish; 5 – mutton; 6 – deer meat; 7 – ostrich meat; 8 – turkey

**Slika 4.** Korišćenje multisenzornog sistema za određivanje vrste mesa: 1 – svinjsko meso; 2 – goveđe meso; 3 – pileće meso; 4 – riba; 5 – ovčije meso; 6 – meso jelena; 7 – meso noja; 8 – meso ćuraka.

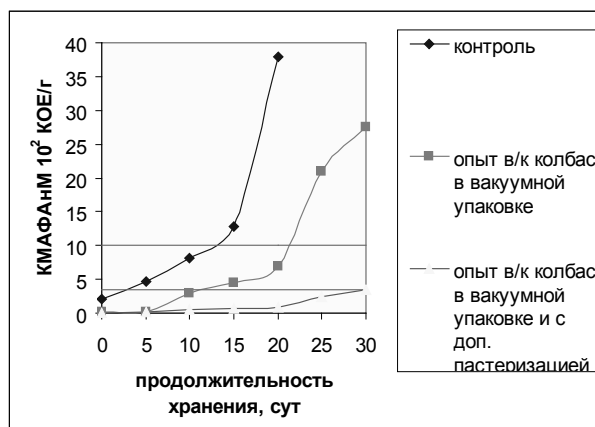
the raw materials of 18% of the studied samples by their raw materials composition did not correspond to the information, indicated on the label.

Production of pig meat is on the increase in Russia at the present time, and production of chilled meat is of great interest due to its best quality traits. Chilled, aged meat with temperature from 0 to 4°C in the core has tender consistency, juiciness, pronounced flavor and aroma more intensive than of defrosted meat. Such meat is better for digestion, and it is more suitable for the manufacture of half-prepared products in pieces.

In Russia, chilled meat is delivered to meat-processing plants mainly in cuts, their shelf life at 0 ... -1°C is 10 days, and in sides – 12-16 days, while chilled meat delivered to Russia from abroad, for example from Argentina, can be stored during 90 days, and from Brazil – 120 days,

At the present time VNIIMP studies changes in sanitary-microbiological indices of chilled pork (boneless, bone-in) during long-term storage. The studied dynamics of changes of microorganisms count in deep layers of meat has shown that microflora penetrated into deep layers of meat from its surface, and this primarily related to motile forms of bacteria (Fig.5).

After the first day of chilling there was no microflora in deep layers of muscular tissue. Up to 12-15 days of storage deep layers of cuts turned to be sterile. During further storage changes in microbiological state were found in deep layers of muscle tissue: the number of lactic acid bacteria



**Figure 5.** Changes in sanitary-microbiological indicators of chilled pork during long-term storage

**Slika 5.** Promene sanitarno-mikrobioloških indikatora u ohlađenom svinjskom mesu tokom dugotrajnog skladištenja

(LAB) and the index of total plate count increased. However, Coli group of bacteria, sulfite-reducing Clostridia, yeast, microorganisms of genera Salmonella, Listeria were not found in deep layers of cuts of chilled pork, stored under vacuum throughout all the period of investigations (up to 35 days). The obtained data will be used for the development of reference values in microbiological control of vacuum-packed meat cuts during long shelf life periods.

The future of meat science is the development of the methods of safety and quality improvement of

meat. It is necessary to combine knowledge about the processes taking place on molecular and cell levels, with our knowledge about the live organism on the whole, to understand more clearly the

mechanisms taking place in tissues of live animals and transformations in these tissues after slaughter. This will give us the opportunity to supply high quality, nutritive and safe products to consumers.

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