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Significance of electromagnetic treatment in production technology of cold smoked sausage

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Abstract

Today there are a number of technological approaches for accelerating the maturation and drying of cold smoked sausage. We propose a new way of intensifying technological process based on electromagnetic treatment of starter cultures and meat products. This paper presents the results of commercial production of cold smoked sausage and reasons for the potential use of electromagnetic treatment for accelerating technological process.

Keywords: cold smoked sausage, technical standards, maturation, drying, production, acidity, forcemeat, starter cultures, electromagnetic treatment.

Introduction

Production technology of cold smoked sausage has been known to mankind for ages mostly used for long-term home conservation of meat collected during seasonal slaughter. The first domestic industries of these meat products emerged in Europe at the end of the XVIII century. Consumers have always been, and are still very much appreciating cold smoked sausage without the second thought of how complicated microbiological and biochemical processes are, ensuring food safety and organoleptic characteristics of a product (Semenova *et al.*, 2012).

Scientists and professionals are well aware of the problems of this technology. "No microbiologist could have invented cold smoked sausage, since its production process is truly monstrous: meat products and fat are stuffed in a casing and stored until the moment of consumption". These are the words by the German scientist, Professor Lothar Leistner, who developed theoretical and practical bases of ensuring microbiological safety and stability of many food products (Semenova *et al.*, 2012).

The progress of the scientific research in the field of biotechnology has led to the development of new technologies, which allow to intensify the production of meat products, improving their organoleptic qualities and significantly increasing the assurance of production of high-quality products, providing more rational processing of meat by-products, etc. Starter cultures containing lactic bacteria, micrococcus and yeast came to be used in production of various kinds of sausage and salted products including poor quality meat in many countries recently. Based on the methods of biotechnological modification, resource-saving technologies of production of cold smoked sausage were developed (Timoshenko, 2010).

Despite a vast amount of positive effects of application of starter cultures, their use in production of cold smoked sausage is rather problematic, since it requires the use of climate chambers, thus having a considerable influence on the cost of the final product.

Currently, among cold smoked sausage manufacturers chemical acidulating with glucono-delta-lactone is common.

Glucono-delta-lactone (GDL) is gluconic acid anhydride. When contacting with water it again

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forms gluconic acid and pH of forcemeat is decreasing disregarding its temperature (Nesterenko, & Reshetnyak, 2012). Still GDL can negatively affect the taste of the product, adding metallic off-flavor, slightly sour and bitter taste, making the texture spongy. It also changes the color of sausage products making it pale in dependence of the amount of GDL. Additionally, high amount of GDL can cause growth of peroxide-producing Lactobacillus species which leads to rancidity and unstable color (Antipova, Tolpygina, Kalachev, 2011).

In connection with the above matter the improvement of cold sausage production technology is necessary. One way is the implementation of new manufacturing processes, which allow to avoid chemical acidulating and use starter products with maximum efficiency (Nesterenko, & Reshetnyak, 2011).

The goal of the research is to improve technological process of production of cold smoked sausage with the use of raw materials and starter cultures induced by electromagnetic treatment.

Materials and methods

For running the experiment three parallel kinds of cold smoked sausage (the first including GDL; the second – starter cultures "Almi 2"; the third – starter cultures "Almi 2" induced by electromagnetic treatment) were produced at the sausage department of CJSC "Meat-packing plant "Tihoretsky" in accordance with TI 006-00422020-2002 of semi-dry cold smoked sausage production to TS 9213-006-00422020-2002 "Semi-dry cold smoked sausage".

Preliminary preparation of meat products for batches 1 and 2 conformed to TI 006-00422020-2002. Preparation of meat products for batch 3 was carried out as follows: premium quality trimmed beef and low-fat trimmed pork in pieces weighing up to 300 g were stacked in carts with layer thickness of 30 cm. The products in carts were induced by electromagnetic treatment for 30 minutes with frequency of 100 Hz. Further preparation of meat products conformed to TI 006-00422020-2002.

Forcemeat is prepared in meat cutters. Treated meat and fat are charged into a cutter in accordance with the recipe in the following order: beef, low-fat pork, food additive containing GDL for batch 1, bacterial preparation for batch 2 and bacterial preparation activated by electromagnetic treatment for batch 3, spices, salt, sodium nitrite (in a solution) and fat.

The total cutting time is up to 3.5 minutes. Completion of the cutting process is determined by the pattern of texture of forcemeat, in which relatively equal sized fat pieces with the dimensions recommended for this particular sausage should be evenly spread. The temperature of forcemeat was minus 3 °C by the end of cutting.

After cutting, forcemeat is stuffed in a fibrous protein casing with diameter of 50 mm. Thereafter linked sausage is sent for heat treatment, which was carried out in two ways.

The first way of heat treatment was applied to experimental batch 1:

1. Sagging was carried out for 24 hours at a temperature of 8 °C;

2. Smoking was carried out with hardwood sawdust for 2 days at a temperature of 22±2 °C, relative air humidity of 92±3% and air velocity of 0.2-0.5 mps in smoking chambers.

3. After smoking, sausage was dried for 7 days at a temperature of 13±2 °C, relative air humidity of 82±3% and air velocity of 0.05-0.1 mps.

Further drying was carried out at a temperature of 11±2 °C and relative air humidity of 77±3% until standard moisture regain.

The second way was applied to batches 2 and 3:

1. Sagging and smoking are combined. The process is carried out in a processing machine for 3-4 days in the following modes: on the first day sausage is kept at a temperature of 22±2 °C, relative air humidity of 92±3% and air velocity of 0.2-0.5 mps. On the second day a small amount of smoke is delivered for 4-6 hours and relative air humidity is lowered to 88±3%. On the third day smoke delivery is intensified and further process is carried out at a temperature of 20±2 °C, relative air humidity of 83±3% and air velocity of 0.05-0.1 mps. The total smoking time is 8-12 hours.

2. After smoking, sausage is dried at a temperature of 18±2 °C and relative air humidity of 82±3% for 24 hours. Further drying is carried out at a temperature of 13±1 °C until standard moisture regain.

Results

During histological examination of treated striated muscle tissue all samples showed structural changes in muscle fibers characterized by lysis of myofibrils. In addition, muscle fibers themselves were fragmented, as shown in figure 1. Connective tissue between muscle fibers and muscle bun-

dles was also in a state of decay being a homogenous protein structure with no distinct color. While measuring pH level in accordance with GOST 26188-84, the readings decreased from 5.6 to 5.4 for pork and from 6.2 to 6.0 for beef (Nesterenko, Sergienko, Reshetnyak, 2011).

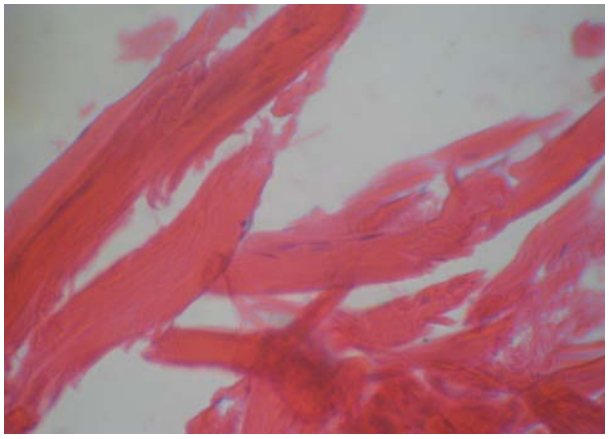

Figure 1. Histological section of treated striated muscle tissue.

While performing microbiological studies of treated meat products in accordance with GOST 10.444.15-94, bacterial content readings also decreased; the results are presented in table 1.

Table 1. Number of colony-forming units depending on the parameters of electromagnetic treatment.

No of sample	Treatment time, min	Frequency (f), Hz	TVC CFU per g (-3)	Coliforms in 0.001 g
c	-	-	$5.9x10^4$	Not found
1	30	10	$1.6 x10^5$	Not found
2	30	100	$1.1 x10^2$	Not found
3	30	200	$4.0 x10^4$	Not found

During production three basic readings of pH, moisture content and total viable bacterial count (TVC) were measured. First readings for all samples were taken after cutting; the results are presented in table 2.

Table 2. PH readings, moisture content and total viable bacterial count (TVC) measured in forcemeat.

Sample	pH	Moisture content	TVC
control	5.7	53.7	$2,8x10^6$
1	5.6	53.75	$2,8x10^6$
2	5.6	53.7	$3,7x10^6$
3	5.5	51.05	$2,1x10^6$

Examination of obtained results reveals the changes in pH value of initial forcemeat. These changes occur due to the alterations in activity of microflora activated by electromagnetic treatment.

Many substances of biological origin are known to have liquid-crystalline structure, e.g. protein myosin which is part of many membranes. There are opinions, that certain structural elements of cytoplasm, e.g. mitochondria, have liquid-crystalline structure that is why anisotropy of magnetic properties is characteristic for them. We do not exclude that liquid crystals being magnetic anisotropic structures of the cell, are oriented under the influence of magnetic field. Being localized in membrane structures of the cell they are responsible for changes in membrane permeability which in its turn regulates biochemical processes (Nesterenko, Reshetnyak, 2012).

Magnetic field influences some physical and chemical properties of water in cells: surface tension, viscosity, conductivity, inductivity, light absorption. Water properties changes lead to the changes in integrated water system with protein molecules, nucleic acids, polysaccharides, lipids. It's determined that magnetic field, changing the energy of the weak interactions, influences supramolecular structural organization of living things. It results in quantitative changes in chemical reactions certain of which proceed with enzymes. There are several types of magnetic fields, thus some of them activate biological objects. Their basis is rotating electromagnetic field (Ignatov *et al.*, 1978).

Decrease in moisture content occurs due to the above mentioned destruction of muscle fibers.

Owing to initial electromagnetic treatment at the stage of preliminary preparation of materials, we managed to reduce total bacterial content of meat products and also, owing to application of activated starter cultures, we obtained forcemeat containing the highest number of desirable microflora against the undesirable. Such results can't be achieved by usual application of starter cultures. This can be seen when comparing TVC readings of control and sam-

ple 2. In this regard, microflora of sample 2 will be less controllable that under the conditions of wrong realization of maturation increases the risk of microbiological defect.

The next measurements were taken after sagging, before smoking, after smoking before drying and on days 3, 5, 11, 15 of drying; the results are presented in table 3.

Table 3. The results of microbiological and physicochemical analysis.

Sample	pH	Moisture content	TVC
Before smoking (after sagging)			
1	5.4	53.25	$2.7x10^6$
2	5.5	53.50	$4.3x10^6$
3	5.3	51.00	$2.4x10^6$
After smoking (before drying)			
1	4.9	50.28	$5.0x10^5$
2	5.3	52.91	$1.6x10^6$
3	5.1	48.99	$9.0x10^5$
Drying day 3			
1	4.8	47.38	$2.9x10^5$
2	5.1	50.10	$8.7x10^5$
3	5.1	45.41	$1.0x10^5$
Drying day 5			
1	4.7	44.83	$5.7x10^4$
2	4.9	44.98	$6.9x10^5$
3	5.0	42.30	$2.0x10^4$
Drying day 11			
1	4.8	42.59	$6.3x10^3$
2	4.8	43.10	$9.7x10^4$
3	4.9	39.13	$4.0x10^2$
Drying day 15			
1	4.8	40.23	$1.5x10^3$
2	4.7	41.83	$2.7x10^4$
3	4.9	37.81	$3.0x10^2$

As you can see in table 3, moisture content of sample 3 reached target value in no more than 40% of cases on drying day 11 or production day 15. The samples 1 and 2 did not reach this value on drying day 15.

The drying process consists of the following stages:

- evaporation on the surface and inside a product;
- transfer of water vapors to the outside environment through a boundary layer (external moisture transfer);
- center-to-surface moisture transfer (internal moisture transfer).

The driving force for external moisture transfer is the difference between partial water vapor pressure on product's surface and in the outside environment.

As a result of external moisture transfer, a water gradient, which is the driving force for internal moisture transfer, is created inside a sausage link.

The consequence of internal moisture transfer is the transport of water-soluble substances and their concentration in the evaporation zone. Thus a center-to-surface concentration gradient is created.

Drying process depends on the velocity of water phase transformation, internal moisture transfer and external moisture transfer through a boundary layer rates. The latter maintains resistance to heat-

and mass-exchanging processes being characterized by high moisture content and low temperature. The thickness of the boundary layer (which is formed immediately at the surface of a product) depends on air velocity inside a chamber.

However, forced air convection is not used for reducing thickness of the boundary layer during drying, since the increase in air velocity leads to uneven drying of outer and inner layers.

Outer layer drying rate under otherwise equal conditions is always higher than that of inner layers. In addition, moisture content of the central layer can be 1.5 or more times higher than that of the outer layer.

The outer layer thickens and shrinks, thus resisting moisture transfer inside a product and slowing down the drying process.

Internal moisture transfer and therefore drying rate depend on characteristics of a product: moisture content and water-to-material bond strength, tissue composition, type of casing, link diameter, etc. Drying rate of the sample 3 was significantly influenced by meat products being induced by electromagnetic treatment, which resulted in partial destruction of muscle fibers, pH decrease and moisture loss.

Conclusions

The advantages of production technology of cold smoked sausage with the use of bacterial starter cultures induced by electromagnetic treatment are optimal for accelerating technological process. When using the given technology, requirements to biochemical properties and microbiological readings of a product are lowered. A possibility emerges to adjust the initial pH of meat. It is possible to use fresh, ripe, mature or frozen meat. The upside of using activated bacterial cultures is their activity, which allows obtaining the same meat products with different initial biochemical parameters under certain conditions of production.

PH level in the range close to isoelectric point of meat proteins (5.1-5.5) creates better conditions for lowering water-binding capacity and, consequently, is optimal for producing nitric oxide pigment responsible for fresh sausage color.

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