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Electrostatic Treatment as a Method of Improving the Quality and Safety of Food

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Abstract: The study describes electrostatic methods of processing food products in order to improve quality and safety. The existing methods of electrostatic treatment do not allow for processing taking into account technological requirements in the production of food products. Considered are new technical solutions for ensuring the safety of semi-finished products and prepared meals using electrostatic treatment.

Key words: Electrostatic field, food processing, environmental friendliness, safety, quality, food preservation

INTRODUCTION

Currently, the consumer is particularly vulnerable to diseases caused by pathogens of food contaminated due to improper storage, transportation and violation of sanitary and epidemiological standards. Thus, products and raw materials necessarily pass not only an organoleptic evaluation but also a microbiological analysis.

The existing variety of methods for processing food products, including using chemical preservatives included in the list of allowed for use in the territory of both the Russian Federation and the European Union has a significant impact on producers. According to the existing norms and rules, simultaneous use of more than two preserving substances for the processing of one product is not allowed.

However, the gradual adaptation of microorganism cultures to the steadily increasing amounts of preserving substances forces manufacturers to use increasingly toxic and unstabilized compounds. As a result, an increasing number of cases of diseases of the gastrointestinal tract, a significant load on the liver and kidneys, characteristic disorders of biorhythms of metabolism, allergic reactions and significant irritations of the skin, accompanied by pain and itching. An alternative way of reagent-free exposure to food is physical and physicochemical methods of treatment (Krasikov, 2000).

Existing methods allow processing with the use of the generated metastable compounds, excess energy in the process of action of the destructive cell. However, these technologies as a rule, besides many undeniable advantages have a number of drawbacks, among which high consumption of electricity. Therefore, the current stage of development of technical solutions requires the development of new, energy-efficient and environmentally friendly technologies for improving the quality and safety of food products (Kuznetsov, 2015a, b; Cherkasova, 1998). Among other methods researchers in the field of non-contact treatment of food products select treatment with an electrostatic field. The accumulated experience and research results allow to determine the potential capabilities of this technology while implementing the most successful theoretically valid designs (Kuznetsov, 2015a, b; Nikiforova, 2015).

MATERIALS AND METHODS

Substantiation of electrostatic treatment methods: The variety of food products offered to consumers leads to the need to develop methodological support for technological processes. The composition, temperature regimes of products have a significant influence on the solution of questions of ensuring the quality and safety of food. The aggregate state of the products greatly influences the method and design features of the processing devices.

The existing technological methods of processing liquid food products are based on the theory of the structure of a double electrical layer. Over this theory, at different times, worked Hermann Helmholtz, Jean Baptiste Perrin, Louis Georgi Gui, David Chapman. During the processing of the results of the studies, scientists confirmed that the charge distribution at the interface between the two phases was determined by the forces of electrostatic attraction which depends on the electric potential and thermal motion of the ions which tend to distribute uniformly throughout the available volume of the liquid phase (Altshuler, 2008).

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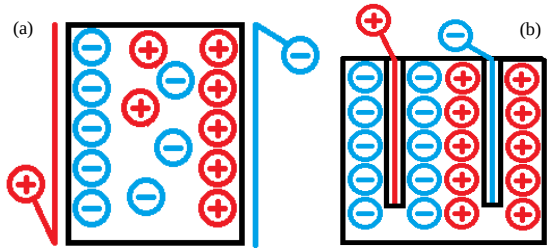

Fig. 1: Model of a single-loop field: a) A multi-circuit; b) Electrostatic field treatment

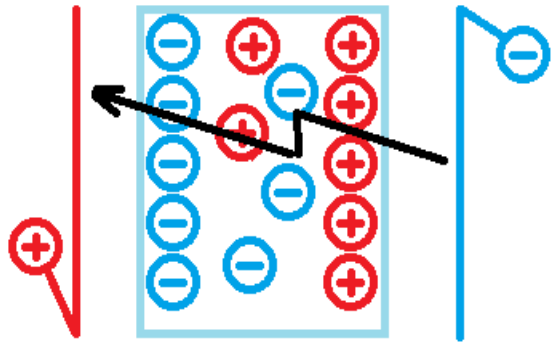

Fig. 2: Model of processing by an electrostatic field of the directed stream (short circuit is shown)

The modern theory of the structure of the double electric layer, developed by the physicist Otto Stern unites all previous theories. Thus in the case of processing a liquid food product through a dielectric material (glass, plastic) the zone of electrostatic action will be limited by the surface of the contact dielectric material at the glass-liquid interface (Shmigel and Sukhovskiy, 2014). For this reason, the use of a disposable electrostatic treatment loop (Fig. 1a) is 2 times less effective than a similar multi-sectional design (Fig. 1b). So, the surface area increases due to the possibility of using both sides of electrodes packed in a dielectric material.

There are schemes of electrostatic treatment without the use of dielectric materials (Nikiforova, 2015) in the form of strictly directed (Fig. 2) or spray liquid product. This creates a high intensity of the electrostatic field but the probability of an electric spark closure of the circuit increases dramatically. This is due to the saturation of the working area with water vapor which means that additional shielding is required.

Unlike technological methods for processing liquid food products, solid products do not require additional insulation so the efficiency of electrostatic treatment directly depends on the duration and intensity of treatment.

The peculiarity of electrostatic treatment is the surface nature of the effect as a consequence, the internal microbiological purity and the content of the product require great attention. This effect is confirmed by numerous industrial installations for treating meat products, fish, eggs and other products in the electrostatic field with the purpose of intensifying the process of smoking and diffusing smoke substances into the food product. It is worth noting that these substances penetrate to a depth of no >3-4 mm under the action of an electrostatic field. As a processing method, the combined technology of electrostatic ionization of air was used with the creation of a programmable air medium, close to sterile characteristics. To carry out the processing, a stand was assembled to ensure the safety of semi-finished and ready-made meals, the schematic diagram is shown in Fig. 3.

During the work of the stand, air with the help of an air compressor through the supply line was fed into a cell connected to a high voltage source. As a result of the electrostatic field formed between the plates, air was treated to form air ions while a ribbed magnetized plate was installed in the lower part of the cell housing to hold large dust particles. During the processing it was necessary not to allow electric spark treatment of air due to the formation of a significant amount of ozone by adjusting the source of high voltage. After processing, air containing air ions was fed from the cell through a conduit to the container in the lower part of which a grid grid was installed on which the food product was placed. At the same time, excess air mass from the container emerged through the hydraulic shutter. Distilled water was used as an aqueous carrier, however, it is permissible to use water corresponding to GOST R 51232-98 “Drinking water. General requirements for the organization and quality control methods” or an aqueous carrier containing low concentrations of a disinfectant solution approved for the food industry for example, dilute aqueous solution of anolyte ank super with a concentration of per 100 mg in active chlorine (an action taken to prevent microbiological contamination of the product through the septum). The inner surface of the cell, a magnetized ribbed plate was periodically washed in running water.

Study of the efficiency of electrostatic processing of semi-finished and ready-made meals: To study the effectiveness of electrostatic processing of semi-finished products and ready-made meals in order to improve the quality and safety, the following products were used, corresponding to GOST: Potatoes (GOST r 51808-2013, potatoes, technical conditions), chicken fillet (GOST 31962-2013, chicken (chicken carcases, chicks, broiler

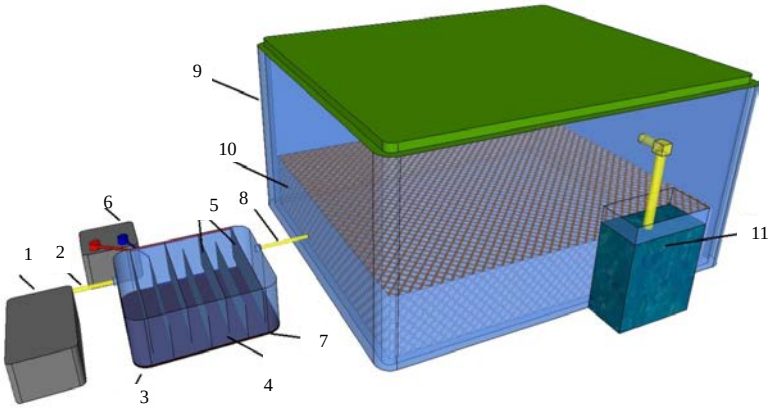

Fig. 3: Schematic diagram of the device for ensuring safety of semi-finished and ready-made meals where: 1-air compressor; 2-supply pipeline; 3-a cell consisting of a body 4, plates 5; 6-high voltage source; 7-ribbed magnetized plate; 8-outlet pipe; 9-Container; 10-mesh grating; 11-water seal

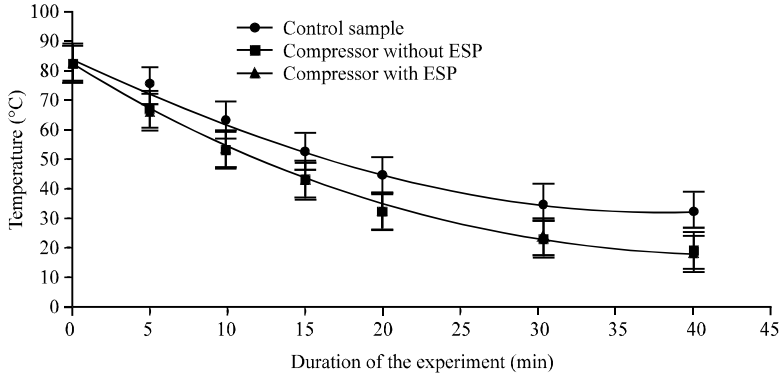

Fig. 4: The dynamics oftemperature change

chickens and their parts), technical conditions), sunflower oil (GOST 1129-2013, sunflower oil, technical conditions) Salt (GOST r 51574-2000), salt, technical conditions) Drinking water (GOST r 51232-98. Drinking water general requirements and methods of quality control).

To obtain meaningful scientific research results, the experiment was reproduced three times. As methods of evaluation, physico-chemical and organoleptic techniques were used. When working, the rules for working with electrical installations were observed.

Finely chopped and breaded chicken fillets were fried at T = 180° C for 15 min, cut into straws, the potatoes were fried at T = 180°C for 10 min, after cooking, the hot dish and garnish were transferred from the pan to a specially prepared container and processed. The results of the average values of the temperature change are shown in Fig. 4. Dependencies can be described by equations. For designs without processing:

$$Y = 0.03x^2-2.5x+83$$

Table 1: Organoleptic control sample main dishes (chicken)

	Experiment duration (days)						
Days	1	2	3	4	5	6	7
Color control sample	U	U	S/d	S/d	S/d	S/d	S/d
The color of the treated sample	U	U	U	S/d	S/d	S/d	S/d
The appearance of the control sample	N	N	A/m	A/m	A/m	T/s	T/s
The appearance of the treated sample	N	N	N	A/m	A/m	A/m	T/s
Odor control sample	N	N	N	M	M	S	S
The smell of the treated sample	N	N	N	N	M	M	S

For samples of past electrostatic processing:

$$Y = 0.04x^2-3x+50.7$$

According to the research, it was determined that electrostatic treatment had no impact on the change of temperature during processing of samples. At the same time, organoleptic control samples for 7 days has revealed changes in the quality of the samples, the results are presented in Table 1 and 2.

Table 2: Organoleptic control sample side dishes (potatoes)

	Experiment duration (days)						
Day	1	2	3	4	5	6	7
Color control sample	U	U	S/d	S/d	S/d	S/d	S/d
The color of the treated sample	U	U	U	S/d	S/d	S/d	S/d
The appearance of the control sample	N	N	A/m	A/m	A/m	T/s	T/s
The appearance of the treated sample	N	N	N	A/m	A/m	A/m	T/s
Odor control sample	N	N	N	M	M	S	S
The smell of the treated sample	N	N	N	N	M	M	S

U-Uchanged; S/d-Sight darkening; S/d-Significant darkening; N-Normal; A/m-Allocation of a moisture; T/s-Traces of spoilage; M-Musty; S-Sharp

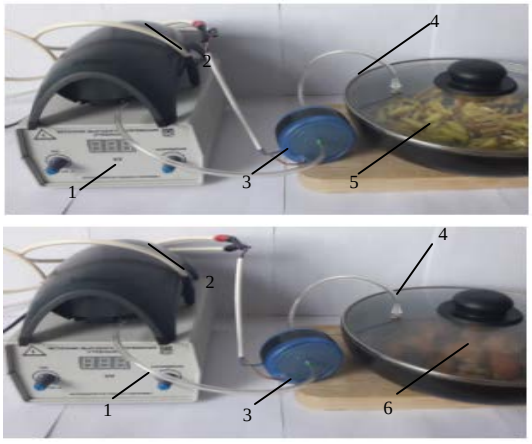

Fig. 5: Installation for electrostatic processing main dish and side dish (1-high voltage source; 2-compressor; 3-block electrostatic processing; 4-pan with lid (with valve) 5-sample chicken; 6-sample side dishes (potatoes)

RESULTS AND DISCUSSION

When testing the stand to ensure the safety of semi-finished products and ready-made meals, technical defects in the design were identified and eliminated. It was suggested to exclude an intermediate operation to shift the main course and garnish from the pan to an individual container. To process and cool the main dish and garnish (Fig. 5) it was suggested to process the product just removed from the plate by connecting the unit directly to the lid. The proposed technical solution will avoid possible microbiological contamination of the product when the product is transferred from the frying pan to the temporary storage container.

As a practical implementation of the research results, the use of compact, portioned containers with a ceramic coating with a tightly docked glass lid with a double check valve system is suggested. The process of preparation and further temporary storage is carried out without a sharp change in the temperature regime while eliminating the entry of microorganisms from the air and complete destruction due to high-temperature processing are at the time of the beginning of cooking on the surface of the product. This technical solution allows us to achieve our goal: to improve the quality and safety of food with a short storage period. Cooling the product through the use of electrostatically treated air will allow you to quickly move the prepared dish or semi-finished product from the working production zone to the storage area.

CONCLUSION

The current stage of development requires the development of new, energy-efficient and environmentally friendly solutions to improve the quality and safety of food. The existing methods of preserving the quality of products, however as a rule, require significant energy and resource costs. The developed technical solution allows to increase the efficiency of use, the level of quality, microbiological safety and the extension of the shelf life of food raw materials and food products of plant and animal origin. The proposed arrangement of the technological process using activators of various designs prevents spoilage processes, extends the shelf life without the use of chemical preservatives.

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