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Article

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USE OF CONSUMER POLYMER C-PET CONTAINERS IN FOOD PRODUCTION TECHNOLOGIES

Different types of consumer containers are used for food packaging: glass, metal, polymer. Polymer containers are in the greatest demand among consumers, due to such advantages as cheapness, small weight, unlimited range of products and volume, pleasant, bright appearance. In the food industry, hard, semi-hard, soft and other consumer polymer containers are used. To use such packaging in technology with high-temperature heat treatment of food products, it must have a heat-resistant barrier layer. Therefore, the object of research is a polymer combined C-PET container, which consists of a semi-rigid container-tray and a heat-resistant multi-layer polymer soft film for its closure. C-PET packaging is made of barrier polymer materials that ensure its mechanical resistance to high temperatures. Therefore, such containers can withstand high-temperature processing and guarantee the tightness of the package and the microbiological stability of the product during storage. Each polymer material has its own specific indicators of heat resistance. The work solves the problem of using the latest polymeric C-PET containers for long-term storage food products, investigates the conditions for preserving the tightness of the containers during heat treatment, which are ensured by the clogging strength parameter. Different types of polymer films for sealing C-PET packaging with the product are also investigated and their mechanical characteristics are compared. In the course of the study, a standard membrane-compensation method was used to measure the clogging strength or depressurization pressure of the package. The essence of the obtained results: the parameters of the use of different types of polymer films of different types were experimentally determined, on the basis of which the type of film was chosen, which ensures the clogging strength of C-PET containers. The results are explained by the fact that the depressurization pressure value obtained will allow to develop scientifically based thermal modes of sterilization and pasteurization for food products in C-PET containers. This will make it possible in practice for enterprises to apply the same regimes and produce high-quality, biologically stable, safe food products with a long shelf life.

Keywords: *polymer packaging, C-PET packaging, heat resistance of polymer films, clogging strength, heat treatment modes.*

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1. Introduction

Polymer containers are widely used in the food industry for packaging liquid, pasty and loose products. Ready-made plastic containers differ in shape, volume and method of closing the package. The shape of the container depends solely on the customer's choice: round, oval, square, rectangular, etc. For polymer containers, the volume and assortment of products does not matter. The most common ways of sealing polymer packaging: foil lid (plate), various types of polymer films, including heat-resistant ones, plastic lid-caps. In some cases, the cap is combined with film or foil.

Advantages of packaging products in polymer containers:

– strength – a plastic container is less susceptible to mechanical damage than polypropylene packaging;

– high temperature resistance – packaging can be used in a wide temperature range. Frozen food is stored in plastic containers at a negative temperature (up to –60 °C), the packaging is heat-sealed and the products are subjected to heat treatment at a temperature of +100 °C and higher;

– convenient format – the consumer does not need additional dishes to use the product from a plastic container. This allows taking it on the road or consuming it on the go.

Airtightness is one of the main requirements for food packaging. The quality and duration of food storage depend not only on the composition of the product, but also on the type and sanitary condition of the packaging. The shelf life of food products depends on whether the packaging is sealed or not. A hermetic container is a container, the design of which, complete with a closure, ensures its impermeability. Packaging (wrapping, packaging, sealing, capping): preparation of products for transportation, storage, sale and consumption using packaging. Capping is the sealing of a container after packing the product in it in order to ensure its safety and create conditions for its transportation and storage. The packaging process itself is the final stage of the

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manufacturing process of any type of product. The causes of product spoilage and a decrease in its quality are: the influence of the external environment – oxygen, moisture, light, temperature, microorganisms and other factors. According to sanitary regulations, products with a long shelf life should be packaged in hermetic types of packaging [1, 2].

PET packaging is one of the most popular types of packaging for various food products among manufacturers and consumers on the market. C-PET is a material with special components that ensure its heat resistance. This is a one-time durable package that competes with metal aluminum containers. Types of C-PET containers are presented in Fig. 1.

Fig. 1. Types of polymeric C-PET containers

Advantages of this type of container:

1. Excellent appearance, the gloss of the packaging gives it the appearance of a premium-class container.

2. Withstands temperatures from –40 to +200 °C and higher. This property is provided by special heat-resistant recipe components, which allows the use of this polymer packaging in various food technologies – from freezing to sterilization.

3. C-PET container has a high barrier, has a low oxygen transmission rate compared to other food polymers.

4. The environmental friendliness of the packaging is provided by the possibility of processing the packaging using existing technologies.

5. It has high inertness on par with a glass container, does not interact with the food product, which ensures its quality during storage [3–5].

Polymeric disposable containers made of C-PET material are used for packaging an unlimited range of food products (first, second dinner courses, sauces, semi-finished food products), which are subjected to heat treatment, for example, sterilization, to obtain long-term storage products, as well as for cooking meals at home conditions in ovens, microwave ovens. Plastic C-PET packaging is heat-resistant and can withstand high temperatures up to 200 °C and above. This type of packaging is made of a multilayer material that contains special heat-resistant components that provide the mechanical strength of containers in a wide range of high temperatures. In the manufacturing technology of C-PET containers, the main operation is thermoforming, which ensures a high degree of crystallization of the material and makes it heat-resistant, durable, protects against deformation, and allows maintaining the shape and size of the package.

Thanks to special formulation barrier components, it is possible to produce C-PET containers that are heat-resistant and impact-resistant, for example, from a polymeric multilayer material PET/RA (polyethylene terephthalate/non-thermoplastic rubber additive). The more layers the material has, the more resistant the package to various external influences [6–8].

Various grades of polymer multilayer films are widely used for sealing polymer containers. The most important polymers for their production are low-density polyethylene (LDPE), polypropylene (PP), polyethylene terephthalate (RETP) [9].

A feature of the technology for the production of polymer films with different desired properties is the use of several technologies: polymer synthesis, film production and production of polymer containers. In the process of manufacturing closure films, various prescription components are introduced into the base synthesized polymer. The composition of the composition or formulation depends on the indicators that the polyethylene film should have during the operation of the container. When compiling a polymer composition, the basis is the conditions for using the material – the temperature minimum and maximum operation, the levels of physical and mechanical properties, the nature of interaction with the product, while the performance characteristics of the material must maintain acceptable values in technologies where it is used and for a certain period of time. For food packaging, the film grades used must be approved by the Ministry of Health. Many food production technologies require heat treatment of the product to increase the shelf life, which severely limits the choice of polymer packaging material in terms of thermal properties.

Polyethylene multilayer barrier films, which include polypropylene PP (PP/PE) – universal polymeric material designed for the production of food packaging with heat resistance properties at temperatures above 100 °C. PP film (PP/PE) is ideal for packaging ready-made first and second dinner courses, culinary semi-finished products and other products for further freezing and processing at high temperatures. The PP film is characterized by resistance to mechanical damage and excellent weldability when sealing containers with the product. To enhance the gas permeability barrier properties, the polyethylene/polypropylene film is produced with a high-barrier EVOH layer. The film can be equipped with a peel effect (light opening effect). Suitable for heating food in a microwave oven (MW), for sterilization and pasteurization of food. Combinations of polymer film materials with various additives are possible, which provide the specified properties of the packaging material: heat resistance, mechanical strength, extensibility, deformation resistance, and others [10–12].

For the microbiological stability of long-term storage food products, it is necessary to ensure the tightness of the container; therefore, an important technological parameter in this case is the sealing strength or the depressurization pressure of the package itself. This parameter depends on the type of closure material, the method of its sealing and other factors. When heated in the apparatus, due to the thermal expansion of the product, there is an excess pressure in the container, which can lead to a violation of the integrity of the package. Therefore, it is important to know the value of the closure strength, which will allow calculating the counterpressure in the apparatus to prevent the integrity of the container [12–14].

The aim of research is to determine the technological parameter of the closure strength for polymer C-PET containers when sealed with polymer films and to select the best option for sterilization, pasteurization of food products in this type of consumer packaging.

2. Materials and Methods

For the study, 3 samples of polymeric semi-rigid C-PET containers were selected:

1) sample No. 1 – two-section container of rectangular section, nominal capacity of sections 280 g and 220 g; container dimensions:

– large section – length 120 mm, width 98 mm, height 40 mm;

– small section – length 120 mm, width 70 mm, height 40 mm;

2) sample No. 2 – single-section container of round section, nominal capacity 400 g; container size: diameter 115 mm;

3) sample No. 3 – single-section container of rectangular section, nominal capacity 250 g; container dimensions: large section – length 135 mm, width 90 mm, height 38 mm.

The container is sealed (sealed) with films of 4 types of polymeric soft heat-resistant material (PET/PE), manufacturer: C.I.P. Industries LTD, Israel, the following brands:

– Sample No. 1 – 05F33ZAFSW;
– Sample No. 2 – S900775;
– Sample No. 3 – 05F30ZHS;
– Sample No. 4 – S14761.

The types of polymer C-PET containers under study are shown in Fig. 2.

The standard membrane-compensation method was used to measure the sealing strength of a container or its depressurization pressure, which occurs during sterilization due to thermal expansion of the product. The schematic diagram of the research stand is shown in Fig. 3.

Fig. 2. Polymer C-PET packaging: *a* – two-section container of rectangular section; *b* – one-section container of round section; *c* – one-section container of rectangular section

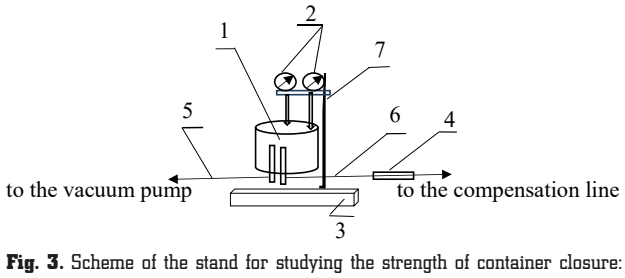

Fig. 3. Scheme of the stand for studying the strength of container closure: 1 – container; 2 – indicator; 3 – calibration plate; 4 – membrane block; 5 – air duct capillary; 6 – capillary to the membrane block; 7 – clamp for containers

The container is connected by capillaries to the compressor and through the membrane block to the compensation line. With the help of a compressor that supplies air to the receiver, and then to the container, excess pressure is created, which was measured using a membrane unit connected to it. The closure strength values were determined from the depressurization pressure of C-PET containers sealed with film. The experiment was carried out under normal conditions (ambient temperature 18–20 °C and atmospheric pressure 0.1 MPa). Such an assumption is possible, since within the operating temperatures of the process of technological processing, the mechanical properties of the container practically do not change [14]. The number of repeated studies of one type of container and film is 5. The results obtained were processed by methods of mathematical statistics.

3. Results and Discussion

During the experiment, the closure strength of 3 samples of polymer semi-rigid C-PET containers was determined, which was sealed with 4 types of polymer films made of soft heat-resistant material (PET/PE). A series of experiments were carried out, the results of which are presented in Table 1.

The obtained experimental data showed that the two-section polymer C-PET container (small section) has the maximum closure strength when it is sealed with a heat-resistant polymer film of Sample No. 2. This type of film has the maximum extensibility. The depressurization pressure for the studied samples of a two-section container with a rectangular cross section, a single-section container with a round cross section, a single-section container with a rectangular cross section is 0.45, 0.44, 0.29 kg/cm^2, respectively. When these values of pressure inside the package are reached, the container loses its tightness.

The advantage of the results obtained is that a comparison was made of the mechanical and thermal characteristics of polymer films that are used by a food manufacturer to seal C-PET containers. Also, the experimental data obtained are fundamental for the development of science-based heat treatment regimes for food products in this type of container.

The limitation of the use of the obtained research values is that when using in the production of heat treatment modes for C-RET containers with the product, one of the parameters of this process, the pressure in the equipment, should be in the range of 0.5–0.6 kgf/m^2, with the experimentally established strength of packing clogging 0.29–0.45 kgf/cm^2. At the same time, the excess pressure that develops in the container is compensated due to the thermal expansion of the product and air. Such parameter values will ensure the tightness of the package, since the film will be in a completely unloaded state. If the pressure in the equipment, during the heat treatment of the product, is less than 0.5–0.6 kgf/m^2, there will be a shortage of finished products due to loss of tightness of the container.

Also, it is necessary to take into account the type of polymer film for sealing and its mechanical and thermal properties, which will also ensure the tightness of C-PET containers. Therefore, when implementing the results of research into the practice of food enterprises, it is necessary to use as a polymer film for sealing C-PET containers, a film similar in characteristics to Sample No. 2, brand S900775, manufacturer Israel.

Directions for further development of the study are that at present, manufacturers are constantly increasing the production of new types of polymer containers, including C-RET, in terms of size, volume, and new types of polymer film are emerging to seal containers with the product.

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Table 1

Closing strength of C-PET polymer containers for different types of polymer soft film

Type of polyethylene heat-resistant film for sealing containers	Strength of container capping (film break pressure), kg/cm^2	Surface area of C-PET film of containers, cm^2	Pressure on the entire surface, kg/cm^2
Two-section container of rectangular section (section big/small)			
Sample No. 1	0.17/0.2 (av)	100.6/72.8	17.1/14.6
Sample No. 2	0.4/0.45	–	40.2/32.8
Sample No. 3	0.17/0.19	–	17.1/13.8
Sample No. 4	0.23/0.37	–	23.1/27.0
One-section container of round section			
Sample No. 1	0.20	78.5	15.7
Sample No. 2	0.44	–	34.5
Sample No. 3	0.28	–	21.3
Sample No. 4	0.30	–	23.6
One-section container of rectangular section			
Sample No. 1	0.17	105.25	17.9
Sample No. 2	0.29	–	30.5
Sample No. 3	0.20	–	21.0
Sample No. 4	0.24	–	25.3

Therefore, the determination of the technological parameter of the closure strength for different types of containers is relevant and in demand in the manufacturers' market. This will allow obtaining modes of heat treatment, sterilization and pasteurization for containers with the product, which will ensure the release of high-quality, sealed products.

4. Conclusions

The paper shows that during the thermal high-temperature processing of food products in the studied types of polymer C-PET containers for sealing, it is best to use a polymer, multilayer, heat-resistant film of Sample No. 2 – S900775. The pressure in the heat treatment equipment should be in the range of 0.5–0.6 kg/cm^2, while the film will be in a mechanically unloaded state, which will ensure the integrity of the package. Experimental data will make it possible to develop and provide manufacturers with such modes of heat treatment of containers with a food product, as a result of which high-quality products, safe to use, and long-term storage will be obtained.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

The manuscript has no associated data.

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