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USE OF POLYMER PACKAGING FOR VARIOUS FOOD PRODUCTS WITH LONG-TERM STORAGE

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Annotation

In the food industry, for thermal preservation of food products, various types of consumer polymer packaging can be used: rigid, semi-rigid, soft, and others. In order for plastic (polymer) packaging to be used for heat sterilization and guarantee long shelf life of food products, it must contain the necessary heat-resistant barrier layer, which will ensure the resistance of the container to high temperatures. Each polymeric material has certain indicators of heat resistance. In the work, we used such types of consumer packaging for food packaging, such as a combined metal can with a polymer lid, C-PET containers. The purpose of the study is to develop the conditions for canning, sterilization modes of food products in the range for new types of consumer polymer for specific thermal equipment. When using various types of containers for thermal sterilization and prevention of physical defects of canned food, it is necessary to take into account such technological features as the sealing strength or depressurization pressure, the sealing method, the presence or absence of a stiffness relief on the lid, the product packaging temperature and other factors. The standard membrane-compensation method was used to measure the sealing strength or the pressure of depressurization of the container, which occurs during sterilization due to thermal expansion of the product. The development of sterilization modes for canned food was carried out in accordance with the approved regulations, which includes an analytical calculation of the mode that ensures the production of industrially sterile canned food, laboratory testing of the selected mode and its production verification. The mode calculation method is based on the data on the heat resistance of the microorganism strain of the test culture, which should guarantee the industrial sterility of canned food. In the work, studies were carried out, as a result of which data were obtained on an important technological parameter of the packaging strength of sealing, without the values of which it is impossible to carry out high-quality thermal sterilization of the product. Scientifically based parameters, high-temperature sterilization regimes for meat, fish, and vegetable products in modern polymer types of consumer packaging have also been developed, which will allow enterprises to produce canned high-quality food products that are safe to use, with high nutritional value.

Keywords: polymer packaging, heat resistance, parameters, closure strength, sterilization modes.

The main property of any packaging is its ability to ensure the safety of product storage. The trends in the development of the packaging industry are, first of all, a decrease in the material consumption of containers, ensuring their logistical compliance, and the rapid growth of online sales. Today, the first place in the world is occupied by the production of polymer packaging. This increases the role of the barrier properties of the container, its safety and ease of use by the end user. The personalization of the packaging solution is being used more and more, the share of production and use of active packaging, that is, products with augmented reality, is increasing. Issues related to the impact of packaging and its waste on the environment are becoming even more important and acute.

Polymer packaging is lightweight and convenient, so plastic materials have become predominant. Large manufacturers also prefer to use plastic containers, since the cost of its production is much lower than for other materials. In recent years, there has been an increase in sales of plastic bottles of small volumes for consumption by the consumer on the go, as well as drinks in group containers - due to a decrease in demand for bottles of large volumes. This trend towards increased use of plastic packaging needs to be monitored in the context of recent demands to ban single-use plastic products. The advantages of polymeric materials are the minimum available cost, the maximum weight ratio of the product and plastic containers, the ease of processing returnable containers and transportation, and compatibility with the production of a wide range of different products.

Polymer packaging materials for food products, depending on the materials used, mechanical stability and degree of strength, are divided into rigid, semi-rigid and soft.

For example, semi-rigid packaging includes: containers such as cups, jars, single- and multi-section pallets made of polypropylene, polyvinyl chloride, high-impact polystyrene, a number of copolymers and coextrudates; this type of packaging is made from multilayer polymer materials with high barrier properties, for example PET/EVOH/CPP (polyethylene terephthalate / ethylene vinyl alcohol / oriented polypropylene copolymer), which are used for sterilized products - canned meat, fish and others. Thin lids for these types of containers are made of aluminum foil with thermoplastic or thermoformed varnish for hermetically sealing containers by heat sealing. Also, semi-rigid packaging includes a combined cardboard container with a polymer coating and aluminum foil as a barrier layer, this group, diverse in size and shape of containers, includes a number of designs such as "Tetra Pak", "Tetra Brik", etc. Dimensions and forms of packaging can be very different - portion packages in the form of a tetrahedron (Tetra Classic), packages with a square and rectangular section Polymeric cardboard combined packaging is not heat-resistant, therefore, heat sterilization in the form of aseptic preservation is used for it (Kovalenko, 2012 ; Polimernay, 2020 ; Vidy, 2020 ; vidy, 2020).

For the manufacture of canned food, the safety of which must be ensured by thermal sterilization, polymer containers based on polyethylene terephthalate (PET), polyethylene, polypropylene, polyamide-11 and other heat-resistant polymeric materials are used. The sterilization process, in this case, is complicated by backpressure modes in autoclaves, because the pressure in the apparatus throughout the entire cycle should slightly exceed the pressure in the container, preventing the bags from inflating (Plastmassovaya, 2020; Verkhivker & Miroshnichenko, 2018).

Ordinary PET packaging withstands low product packaging temperatures of 70-75°C, if the temperatures are higher, then irreversible deformation of the container occurs. For the production of PET packaging company Constar International uses a three-layer polymer structure with a thermal barrier layer of MXD6 nylon and an oxygen scavenger. This passive-active barrier system Oxbar is designed for packaging juices, hot-packed food products. Constar designs bottles to withstand tunnel pasteurization with a longer neck that expands to relieve pressure and a main structure that retains the shape and strength of the closure. The temperature limits of PET are critical for "hot filling" or pasteurization. Polyester supplier Kosa solves this problem with Polyclear 2201 PET copolymer and Polyclear 2202 PET/PEN copolymer. In both cases, the heat resistance is higher than that of plain PET. The 2201 and 2202 grades are reported to withstand up to 1980°F (920°C), far exceeding the usual "hot filling", pasteurization and high temperature sterilization range. For preservation of food products in PET containers, and these are juices, drinks, sauces, seasonings, pastes, ketchups, beer, various methods of thermal sterilization are used: aseptic preservation; "hot filling" of liquid, pasty products; juice pasteurization (Verkhivker et al., 2020; Butylkii, 2020; Trunov, 2020; Gustova & Kry`lova, 2020).

Soft polymer canning containers are the most popular packaging with the consumer, as a rule, transparent or opaque flexible packaging in which the product can be stored for a long time without refrigeration. Doy-packs (doy-pack, pouch) made of combined polymeric materials are a prominent representative of soft polymer packaging. There is a fold in the bottom, which, when the container is filled with the product, moves apart, forming a bottom, which allows the bag to stand. It is used for packaging liquid, pasty and flowing products (mayonnaise, ketchup, sour cream, condensed milk), for packaging baby food.

An interesting and promising is the soft polymeric packaging “retort bags”, which are made of special multilayer films, which must be neutral in their properties to food products, heat sealable, without shrinkage and heat-resistant at temperatures of at least 121°C, for the time required for sterilization. Packaging for autoclave sterilization is a rectangular flexible laminated bag made of polymeric materials (aluminum foil laminated with layers of polymeric materials (laminates) based on polymeric films without the use of foil) with four hermetically sealed seams, in which the food product can be subjected to heat treatment. “Retort bags” are made from 2-4 layer laminated film with a thickness of 80-160 microns. Manufacturers are seeking to replace aluminum foil with more technologically advanced and cheaper barrier materials, such as EVOH or multilayer barrier film consisting of PET/Al/Bonyl/PP, PP/Bonyl/CPP DuPont, PP-polypropylene, CPP-oriented polypropylene). Such a composition of the material allows such containers to be immersed in an autoclave at a temperature of 120-130°C for 30-60 minutes. This is a light, high-quality, durable packaging, convenient to use, in which food products are packaged (canned first and second lunch dishes, animal feed, and others) with a long shelf life of up to 2 years (Butylkii, 2020; Trunov, 2020; Gustova & Kry`lova, 2020; Karyakin, 2020).

When using new types of polymer containers for sterilizing canned food and preventing physical defects in finished products, it is necessary to take into account the technological features of the cans, such as the strength of the container’s sealing or the pressure of its depressurization, which depend on the type of container, the method of its sealing, the presence or absence of a relief on the lid, and the filling temperature. Product and other factors. It has been scientifically proven that the parameter of container closure strength increases with a decrease in the diameter of the container neck, with the presence of a stiffness relief on the surface of the lids. If a polymer container made of heat-resistant barrier materials is used for sterilization of canned food, then the parameter capping strength, depressurization pressure is of great importance, since knowing their values it is possible to prevent the physical rejection of canned food and effectively carry out the sterilization process (Flaumenbaum et al., 1986).

The novelty of the research lies in the fact that technological parameters and sterilization modes have been developed for a range of products that are packaged in metal containers with a lid made of polymeric soft heat-resistant barrier material (PET/PE), C-PET containers for specific thermal equipment.

Research objectives: determination of the parameter - sealing strength or depressurization pressure for metal containers with a lid made of polymeric soft barrier material (PET/PE), C-PET containers; - conducting thermophysical studies to study the heating of food products and the development of sterilization modes for canned food "Smoked Sprats in Oil", "Ukrainian Borsch", "Porridge with Meat", in the studied types of polymer containers in a vertical autoclave B6-KAV-2.

The object of study is a metal can № 2, the nominal capacity of the can is 175,0 g, the external nominal diameter is 103,0 mm with a lid made of a soft polymeric barrier material (PET/PE) with a ring; C-PET container two-section, capacity - 350 g. Types of containers are shown in fig. 1 and 2:

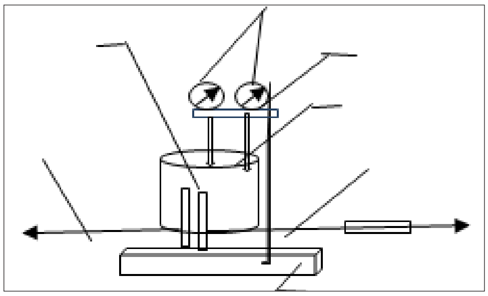
Figure 1: Metal jar with a lid made of heat-resistant polymer material

Figure 2: Polymeric packaging type C-PET two-section

Research Methods

The studies were carried out in the food sterilization laboratory of the Odessa National Academy of Food Technologies. The standard membrane-compensation method was used to measure the strength of the closure of containers or the pressure of depressurization of lids that occurs during sterilization due to thermal expansion of the product. 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 magnitude of the deformation of the lid was measured with a lever indicator of a mechanical type, and the strength of the closure of the container with a manometer. Measurements were made through 0,01 MPa. After maximum deflection of the center of the lid and maintaining the tightness of the container, the internal pressure was reduced to 0,1 MPa and the presence or absence of residual deformation of the lid was determined with an indicator. 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 (Shtukan, 1992).

The schematic diagram of the research stand is shown in fig. 3.



to the vacuum pump to the compensation line 3

Figure 3: Scheme of the stand for studying the deflection of the center of the lid and the strength of the closure of the container

1-container; 2-indicator, 3-surface plate; 4-membrane block; 5-capillary duct; 6-capillary to the membrane block; 7-clamp for containers

The development of sterilization modes for canned food was carried out in accordance with the requirements of the current instructions. The performance of work according to the instructions includes an analytical calculation of the mode, which ensures the production of industrially sterile canned food, a laboratory test of the selected mode and its production verification. For the analytical calculation of sterilization modes, the change in product temperature during sterilization is taken into account. For practical application, there is a calculation method based on an analytical comparison of the equivalence of the required lethality with the actual one for a given sterilization mode at the point of the product that is the least heated during the heat treatment of canned food. Any of the methods for calculating the regime relies on data on the heat resistance of the strain of microorganisms of the test culture, which should guarantee the industrial sterility of canned food. Sterilization modes were developed for canned food "Smoked

Sprats in Oil", "Ukrainian Borscht", "Porridge with Meat" in the studied types of polymer containers in a B6-KAV-2 vertical autoclave (Flaumenbaum et al., 1986; Shtukan, 1992; Babarin et al., 1987; Rukovodstvo, 2011), in which water is used as a heating and cooling medium.

Research Results

The results of studies to determine the closure strength or critical overpressure of new types of polymer heat-resistant containers are shown in fig. 4:

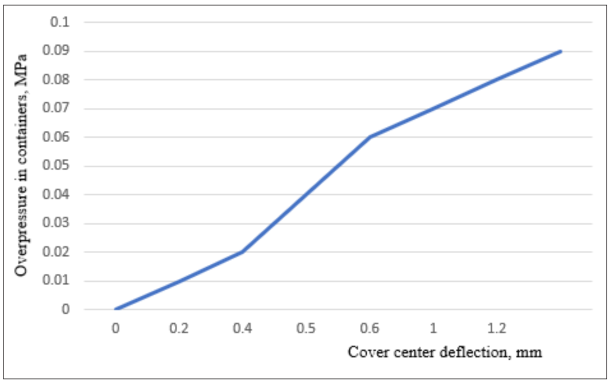


Figure 4: Dependence of the deflection of the center of the lid (film) on the magnitude of excess pressure for a metal container with a lid made of polymeric material and a two-section C-PET container

The experimental data obtained, shown in fig. 4 showed that the sealing strength of a metal container with a polymer lid, a two-section C-PET container, which is sealed with a polymer heat-resistant film, is 0,09 MPa, and the maximum deflection of the center of the lid and film is 1,15 mm and does not give permanent deformation of the container and lid. When the pressure reaches more than 0,09 MPa, depressurization of two types of containers occurs. Therefore, during thermal sterilization of products in the packages under study, the cooling modes should be calculated in such a way that the pressure drop in the apparatus and inside the container with the product does not exceed a certain experimental value, otherwise the container will depressurize, i.e. physical defect of the product. Thus, the maximum pressure that is formed in the container with products during sterilization should not exceed 0,09 MPa. The modes of heat treatment of food products in these types of containers were also developed:

1. The mode of heat treatment of canned food "Smoked sprats in oil" in the B6-KAV-2 autoclave, the product is packed in a metal container № 2 with a lid made of heat-resistant polymer material PET/PE, with a capacity of 175 g. The obtained parameters are presented in table 1:

<table>
<tr><th>Time, min</th><th>Autoclave water temperature, °C</th><th>Autoclave pressure, MPa</th></tr>
<tr><td>0</td><td>40</td><td>0</td></tr>
<tr><td>5</td><td>70</td><td>0,060</td></tr>
<tr><td>10</td><td>100</td><td>0,130</td></tr>
<tr><td>15</td><td>120</td><td>0,175</td></tr>
<tr><td>20</td><td rowspan="8">120</td><td rowspan="8">0,180</td></tr>
<tr><td>25</td></tr>
<tr><td>30</td></tr>
<tr><td>35</td></tr>
<tr><td>40</td></tr>
<tr><td>45</td></tr>
<tr><td>50</td></tr>
<tr><td>55</td></tr>
<tr><td>60</td><td>100</td><td>0,175</td></tr>
<tr><td>65</td><td>80</td><td>0,130</td></tr>
<tr><td>70</td><td>60</td><td>0,100</td></tr>
<tr><td>75</td><td>50</td><td>0,080</td></tr>
<tr><td>80</td><td>40</td><td>0,01</td></tr>
</table>

Table 1: Parameters of the sterilization process of the product "Smoked sprats in oil" in the B6-KAV-2 autoclave using metal containers № 2

$\frac{15\text{–}40\text{–}25}{(120\pm1)\ ^\circ C}$ $(0{,}180\pm0{,}10)$ MPa (pressure in the autoclave according to table 1)

When developing this mode of sterilization, the parameters of the process in an autoclave were determined: sterilization temperature 120±1°C; the autoclave heating time to the sterilization temperature is 15 minutes, the actual sterilization time is 40 minutes, the autoclave cooling time is 25 minutes. These microbiological parameters will ensure the industrial sterility of canned food; the maximum pressure in the autoclave is 0,180±0,10 MPa and the tabular pressure values will help prevent the occurrence of physical defects in canned food.

2. The mode of heat treatment of canned food "Borsch "Ukrainian", "Porridge with meat" in the autoclave B6-KAV-2, the product is packed in a two-section C-PET container, which is sealed with a polymer film, with a capacity of 350 g. The obtained parameters are presented in table 2:

<table>
<tr><th>Time, min</th><th>Autoclave water temperature, °C</th><th>Autoclave pressure, MPa</th></tr>
<tr><td>0</td><td>40</td><td>0</td></tr>
<tr><td>5</td><td>70</td><td>0,06</td></tr>
<tr><td>10</td><td>80</td><td>0,09</td></tr>
<tr><td>15</td><td>90</td><td>0,11</td></tr>
<tr><td>20</td><td>100</td><td>0,14</td></tr>
<tr><td>25</td><td>120</td><td>0,175</td></tr>
<tr><td>30</td><td rowspan="12">120</td><td rowspan="12">0,180</td></tr>
<tr><td>40</td></tr>
<tr><td>45</td></tr>
<tr><td>50</td></tr>
<tr><td>55</td></tr>
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<tr><td>80</td></tr>
<tr><td>85</td></tr>
<tr><td>90</td><td>100</td><td>0,175</td></tr>
<tr><td>95</td><td>80</td><td>0,130</td></tr>
<tr><td>100</td><td>60</td><td>0,100</td></tr>
<tr><td>105</td><td>50</td><td>0,080</td></tr>
<tr><td>110</td><td>40</td><td>0,01</td></tr>
</table>

Table 2: Parameters of the sterilization process of products "Ukrainian Borsch", "Porridge with Meat" in the B6-KAV-2 autoclave using a two-section C-PET polymer container

$$\frac{25-60-25}{(120\pm1)\ °C}\ (0{,}180\pm0{,}10)$$

MPa (pressure in the autoclave according to table 2)

A feature of the development and calculation of this sterilization mode is that the products "Ukrainian Borsch", "Porridge with Meat" are sterilized simultaneously, but these products have different lethality, which ensures industrial sterility, so the product sterilization mode with the maximum lethality is selected, i.e. .mode for the product "Porridge with meat" This is due to the different heating speed of the product due to its different consistency.

Conclusions

When using the studied new types of polymer containers for sterilizing food in autoclaves, it is necessary to start reducing the pressure in the apparatus at the stage of cooling at a temperature not exceeding 85°C. At all stages of heat treatment in an autoclave, it is necessary to ensure that the difference between the pressure in the apparatus and the pressure in the container with the product is not more than 0,09 MPa to ensure the integrity of the container with the product. Under these conditions, the lid of the container is in an unloaded state, which is necessary to prevent depressurization of the cans with the product.

References

1. Kovalenko O. Upakovka novogo pokoleniya. Plastik Zhurnal [Iternet]. 2012 May [cited 2012 Jul 20]; 30(5): [about 5pp.]. Available from: https://www.plastics.ru/pdf/journal/2012/05/Kovalenko.pdf (in Russian)
2. Polimernay tara [Iternet]. 2020 Feb. Available from: https://znaytovar.ru/s/Polimernaya_tara.html (in Russian)
3. Vidy i tipy polimernoy tary. Referat Baza znanij Allbest [Iternet]. 2020 Feb. Available from: https://knowledge.allbest.ru/marketing/3c0a65635b2ad78b5c43b88421306d37_0.html (in Russian)
4. Pishhevayaupakovka: vidy, tekhnologii proizvodstva i tendenczii razvitiya otrasli. Stat`ya [Iternet]. 2020 Feb. Available from: https://www.kp.ru/guide/pishchevaja-upakovka.html (in Russian)
5. Plastmassovaya i kombinirovannaya tara dlya produktov asepticheskogo konservirovaniya, vakuum-upakovka, upakovka dlya MGS. Stat`ya [Iternet]. 2020 Feb. Available from: https://poznayka.org/s40223t1.html (in Russian)
6. Verkhivker Y.G, Miroshnichenko E.M. Modern types of consumer packaging and food packaging. *Journal Biochemical Engineering & Bioprocess Technology*. 2018 Aug; 35(3):52-56.
7. Verkhivker Y.G. et al., (2020). Commodity approach to materials when manufacturing containers for food oils. *JOJ Material Sci, 6*(3), 0042-0048. DOI:https://juniperpublishers.com/jojms/JOJMS.MS.ID.555687.php
8. Butylkii z barernogo PET. Statya [Iternet]. 2020 Feb. Available from: http://newchemistry.ru/letter.php?n_id=1617 (in Russian)
9. Trunov V. Upakovka i oborudovanie dlya fasovki i upakovki sokov. Statya [Iternet]. 2020 Feb. Available from: https://cyberleninka.ru/article/n/upakovka-i-oborudovanie-dlya-fasovki-i-upakovki-sokov (in Russian)
10. Gustova T, Kry`lova V. Innovaczionny`e tekhnologii konservirovaniya produktov pitaniya v polimernoj potrebitel`skoj tare. Statya [Iternet]. 2020 Feb. Available from: https://cyberleninka.ru/article/n/innovatsionnye-tehnologii-konservirovannyh-produktov-pitaniya-v-polimernoy-potrebitelskoy-tare (Russian)
11. Karyakin K. Retort – paket: Speczial`nom vy`puske Unipack Ru. J elect. [Iternet]. 2020 Feb. Available from: https://article.unipack.ru/2270 (in Russian)
12. Flaumenbaum BL, Tanchev SS, Grishin MA. Osnovy konservirovaniya pishevyh produktov. Moskva: Agropromizdat; 1986. 496 p. (in Russian)
13. Shtukan E.M. Razrabotka uslovij konservirovaniya pishevyh produktov v obzhimnoj steklyannoj tare tipa II v nepreryvno-dejstvuyushhikh apparatakh otkrytogo tipa [dissertation]. Odessa, UA; Odesskij institut pishhevoj promyishlennost; 1992. 173 p. (in Russian)

14. Babarin VP, Mazokhina-Porshnyakova NN, Rogachev VI. Spravochnik po sterilizaczii konservov. Moskva: Agropromizdat; 1987. 320 p. (in Russian)
15. Rukovodstvo po razrabotke rezhimov sterilizaczii i pasterizaczii konservov i konservirovannyh polufabrikatov. Moskva: VNIIKOP; 2011. 93 p. (in Russian)