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VERIFICATION OF MULTIFUNCTIONAL STERILIZER OPERATION BASED ON QUALITATIVE EXAMINATION OF FINISHED PRODUCT APPEARANCE USING COMPUTER IMAGE ANALYSIS

Summary

During the operation of equipment for sterilization many technical factors occur which affect manufacturing process directly influencing finished product quality. Product evaluation of the finished product will enable to verify indirectly operation of a prototype construction of multifunctional sterilizer. The article is presented in a photographic documentation that allows to determine qualitatively the impact of the technological process on the appearance of final product, by observing adverse phenomena such as scorching or excessive accumulation of fat on the canned surface. Tests were conducted for tinned meat that were exposed to heat treatments in a multifunctional sterilizer at 131°C (K2) and tins whose recipes were identical but sterilized under industrial conditions at 121°C (K1). The results showed that for the tested tinned meat the change in the parameters of the fixation process did not influence the sensory acceptability factor of the product which is appearance.
***Key words**: sterilizer, food products, computer image analysis*

WERYFIKACJA PRACY WIELOFUNKCYJNEGO STERYLIZATORA W OPARCIU O JAKOŚCIOWE BADANIA WYGLĄDU PRODUKTU GOTOWEGO Z WYKORZYSTANIEM KOMPUTEROWEJ ANALIZY OBRAZU

Streszczenie

W trakcie eksploatacji urządzeń do sterylizacji występuje wiele czynników technicznych wpływających na proces technologiczny, który bezpośrednio wpływa na jakość gotowego produktu. Ocena wyrobu gotowego produktu pozwoli w pośredni sposób zweryfikować działanie prototypowej konstrukcji wielofunkcyjnego sterylizatora. W artykule przedstawiono w formie dokumentacji fotograficznej, która pozwoliła w sposób jakościowy określić wpływ procesu technologicznego na wygląd produktu końcowego, poprzez obserwacje niekorzystnych zjawisk, takich jak np. przypalenie, czy też nadmierne gromadzenie się tłuszczu na powierzchni konserw. Ponadto przedstawiono wyniki komputerowej analizy obrazu konserw mięsnych w postaci histogramów przedstawiających wielkość pęcherzyków powietrza w konserwach. Badania przeprowadzono dla konserw, które zostały podane procesom cieplnym w wielofunkcyjnym sterylizatorze w temperaturze 131°C (K2) oraz konserw recepturowo identycznych, ale poddanych procesom sterylizacji w warunkach przemysłowych w temperaturze 121°C (K1). Wyniki badań wykazały, że dla badanych konserw mięsnych zmiana parametrów procesu utrwalania cieplnego nie miała wpływu na sensoryczny czynnik akceptowalności produktu, jakim jest wygląd.
***Słowa kluczowe**: sterylizator, produkty spożywcze, komputerowa analiza obrazu*

1. Introduction

In order to verify a design of the prototype device, a number of experimental studies on the real object should be carried out. In the literature there are many publications presenting the methodology of experimental research which aim at verifying the structure in terms of strength and methodology of functional tests in order to determine the parameters of operation of the device [8, 10, 11]. All these tests are performed to verify the device from the mechanical side. Devices used in food industry serve to perform technological processes in order to achieve the assumed parameters of finished product. The quality of product demonstrates the correctness of technological process in device. Therefore, in the final evaluation of the device, the quality of the finished product is important, which will indirectly evaluate the prototype construction of the food machinery [1].

Multifunctional sterilizer in food industry will be used to carry out inter alia sterilization of food products. This process involves a very intensive thermal impact on product. The process temperature ranges from +115 to +121°C or +130 to +145°C. The purpose of food sterilization is to fix it by destroying all microorganisms and their spore forms [4, 5, 9]. Successful sterilization process should ensure the preservation of health safety of canned food, high sensory quality and commercial attractiveness. The sensory acceptability of food is extremely important because a person feels contented with eating the food he likes. Appearance is one of the factors for evaluating product quality. This parameter can be determined using computer image analysis. This method in food testing is widely used.

2. Subject of study

The subject of study included a multifunctional sterilizer, which was developed in cooperation with the Industrial Institute of Agricultural Engineering and Poznan University of Technology and Spomasz Pleszew S.A. The work was carried out under the INNOTECH project co-financed by the National Center for Research and Development. The device, it assumes, among others, shortening of a duration of sterilization or pasteurization by changing process parameters. In addition, the use of ergonomic loading and un-

loading systems, reduction of heating demand, electricity, as well as post-heating heat management [2]. The prototype construction of the sterilizer is shown in Fig. 1.

Photo / Fot. FMS Spomasz Pleszew

Fig. 1. Real view of prototype of sterilizer
Rys. 1. Widok rzeczywisty prototypu sterylizatora

3. Aim and test method

The aim of study was to verify if the change in the operating parameters of the sterilizer has an impact on the appearance of final product. The studies were conducted to compare products that were subject to heat treatment in an innovative industrial sterilized canning machine. The results of study have allowed us to assess whether the sensory acceptability factor of appearance is fulfilled. The study included photographic documentation that allowed to determine qualitatively the impact of technological process on the appearance of final product, by observing unfavorable phenomena such as scorching or excessive accumulation of grease on canned surfaces. In addition, computer image analysis was used to determine the impact of sterilization parameters on product quality. For this purpose, a photographic documentation of canned sections was made, illustrating the air bubbles present in their contents, whose presence depends on the technological process. In literature, microscopic image analysis was used inter alia. to determine the effect of xanthan and arabic gum on diameter and distribution of air bubbles in foams obtained on the basis of egg white [7], size distribution of air bubbles in the apple puree [3], and measuring the marbling of beef [6]. Photographic documentation was done on a computer image analysis bench (Fig. 2), which is located in the Industrial Institute of Agricultural Engineering in cooperation with Research and Development of Food Machinery and Equipment. Image analysis station (Fig. 2) consisted of a camera (Grasshopper GS3-U3-23S6C) (1) with the matrix 1/1.2" for image recording, additional lighting (3) in order to illuminate the test sample and a portable computer (2), with specialized software FlyCapture2 Camera Selection.

The research was conducted using canned meat purchased directly from the producer. The research material included raw canned (Fig. 3a), which have been sterilized in a multi-purpose sterilizing device (Fig. 3b), which was marked as „K2". On the other hand, ready-made tins prepared by the manufacturer were used as reference samples - marked as „K1". All of the products used in this work came from the same production batch.

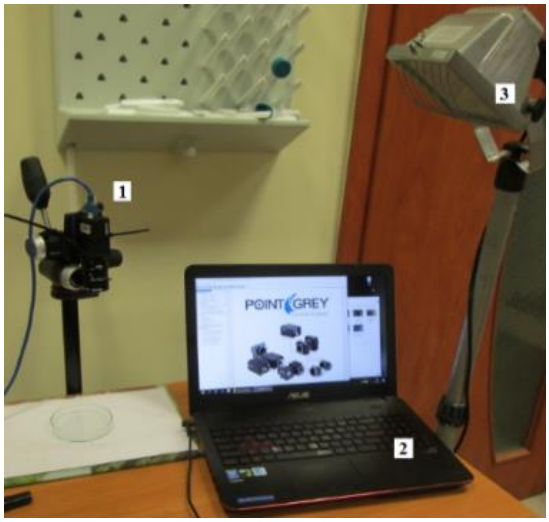


Photo / Fot. A. Bieńczak

Fig. 2. The test stand for the computer image analysis
Rys. 2. Stanowisko do komputerowej analizy obrazu

Canned raw tagged as "K2", have been subject to thermal processes in prototype sterilizer (Fig. 1) in temperature of 131°C. On the other hand, canned meat designated as "K1" as an attempt to reference samples sterilized at the factory at a temperature of 121°C. For both types of tins pictures were taken using 20 packages of product.

a) b)

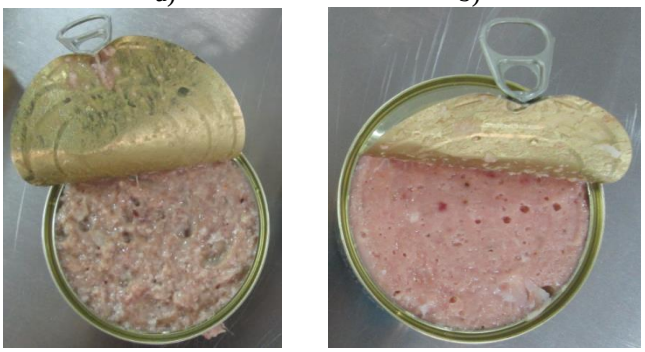


Photo / Fot. A. Bieńczak

Fig. 3. Meat preservative a) before heat treatment, b) after sterilization process
Rys. 3. Konserwa mięsna: a) przed procesem cieplnym, b) po procesie sterylizacji

The product, when taken out of the package, is crossed in a vertical plane. For one of the planes, a photo was taken (1026x964 resolution) with a camera (Grasshopper GS3-U3-23S6C) under constant lighting conditions for each sample. JPEG files were saved and then exported to Autodesk INVENTOR for analysis. In the first stage, the blisters in the picture were drawn to calculate their surface areas. The data obtained in this way, containing the air bladder surface areas, was imported into Excel in which they were converted to substitute diameters. The conversion of this diameter was made by assuming an ideal bladder circle [7]. Based on the obtained results, the distribution of air bubble diameters in histograms for both trials was determined. For each case the average bladder diameter was determined with standard deviation. In addition, descriptive measures such as coefficients of variability, asymmetry and concentration were determined. These parameters are tabulated for canned foods K1 and K2 for comparison.

4. Research results and analyses

In Table 1 three lists of tinned meat "K1" and canned samples "K2" are presented. It has been observed that the canned samples "K1" differ visually in air bubbles, the size of fat agglomerations and the presence of the size of meat pieces. This may be due to the use of meat that is not a homogeneous product. In case of canned "K2" no difference in appearance was observed than in reference products. Moreover, no adverse effects of product scaling and excessive accumulation of fat on the canned surface were observed. The fat accumulated on the surface of tins to a small extent in both cases.

Table 1. View of samples of tinned meat "K1" and "K2" in the package

Tab. 1. Widok próbek konserwy mięsnej „K1" i „K2" w opakowaniu jednostkowym

No	„K1"	„K2"
1.		
2.		
3.		

Source: own work / Źródło: opracowanie własne

In Fig. 4 a cross section of canned meat is shown, which shows 3 different characteristic areas of tested products. Black marked the larger pieces of meat in tin, yellow with empty air bubbles and red agglomerations of fat found in the tin.

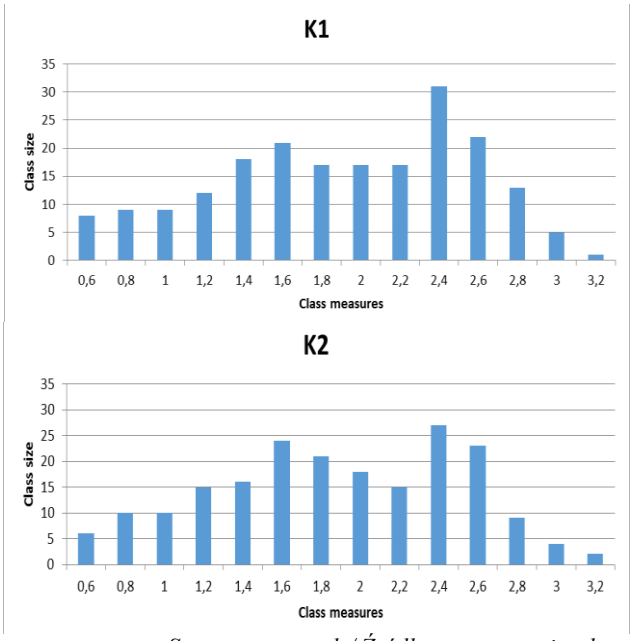
Source: own work / Źródło: opracowanie własne

Fig. 4. The view of an exemplary cross-section of canned meat

Rys. 4. Widok przykładowego przekroju poprzecznego konserwy mięsnej

These areas were different within the unit package depending on the location of the photograph and between the different cans coming from the same batch and subject to the same process. All characteristic divergences were the same for both "K1" and "K2" samples. By analyzing the cross section of canned air, it was observed that the air bubbles occupy the largest area of the examined image. As a consequence, it was decided in the further stage of the work to analyze the distribution of air bubble diameters in the canned area using a histogram.

In Fig. 5 and Table 2 the values of parameters characterizing the diameter of air bubbles are shown. The results show that distribution of bubbles in K1 and K2 is similar. It has been observed that the greatest abundance was observed for blisters with a diameter of about 2.4 [mm]. In addition, there was a decrease in the number of blisters with a diameter of about 3 [mm] and about 3.2 [mm]. Both K1 and K2 can predominate blisters with a diameter of approximately 0.6 to 2.2 [mm]. For both groups, the coefficient of variation is over 33%, which suggests a large variation in air bubble diameters in canned samples that show left-handed asymmetry. In addition, the concentration factors for canned "K1" and "K2" determined for obtained histograms are similar and vary by 0.02. Image analysis shows that changing the sterilization process parameters does not affect the final product.



Source: own work / Źródło: opracowanie własne

Fig. 5. The diameter distribution of air bubbles in canned „K1" and „K2"

Rys. 5. Rozkład średnic pęcherzy powietrza w konserwie „K1" i „K2"

Table 2. Descriptive measures for the distribution of bubbles in the air „K1" and „K2"

Tab. 2. Miary opisowe dla rozkładu średnic pęcherzy powietrza w konserwie „K1" i „K2"

Parameter	Canned meat "K1"	Canned meat „K2"
Arithmetic average [mm]	1,91	1,88
Standard deviation [mm]	0,64	0,63
Variation coefficient [%]	33,8	33,5
Asymmetry coefficient	-0,12	-0,07
Concentration factor	2,12	2,10

Source: own work / Źródło: opracowanie własne

5. Summary

As a result of research, it was found that any discrepancies in the appearance of the examined tinned meat resulted, among others from the formulation of the product, including the heterogeneity of the meat product or the degree of mixing (Indicated in Fig. 4). During the research, no scattering and excessive accumulation of fat on the surface was observed. Based on the analysis of the image, it was found that the tested canned foods have a similar distribution of bladder diameter. In view of the above, it was found that for the tested tinned meat the change of the parameters of the fixation process did not influence the sensory acceptability factor of the product which is the appearance.

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