APARATURA
BADAWCZA I DYDAKTYCZNA

A stand for testing the sterilization process of food raw materials used in the production of dietary fibers

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ABSTRACT:

The paper presents a stand for testing the sterilization process of food raw materials. The controlled parameters are sterilization time, soaking temperature, steam temperature. In order to verify the efficiency of the sterilization process, depending on the mentioned parameters the quantity of microorganisms as well as yeasts and molds in cocoa shells was investigated in an accredited laboratory.

Stanowisko do badań procesu sterylizacji surowców spożywczych stosowanych przy produkcji błonników pokarmowych

Słowa kluczowe: sterylizacja, stanowisko badawcze, surowce spożywcze

STRESZCZENIE:

W pracy przedstawiono stanowisko do badań procesu sterylizacji surowców spożywczych. Umożliwia ono sterowanie takimi parametrami jak czas sterylizacji, temperatura wygrzewania, temperatura pary wodnej. W celu weryfikacji skuteczności procesu sterylizacji w zależności od zastosowanych parametrów wykonano badania liczby drobnoustrojów oraz drożdży i pleśni w akredytowanym laboratorium.

1. INTRODUCTION

The sterilization process in the production of food products ensures bacteriological safety of the product. In the case of production of fibers, the raw material is usually a waste material from another production process [1]. The raw materials include cocoa shell, oat shell, dried apple etc. Each new batch of the same raw material may differ in terms of moisture content, size of grains, condition of their surface or thermal conductivity. In turn, these characteristics determine the process parameters of sterilization [2-4].
The basic parameter determining the efficiency of grinding of the raw material is the moisture content of ca. 8% on average. In order to achieve grain size of 50 µm in the grind mills, the moisture content should not exceed 4-6%. Therefore, it is necessary to additionally dry the raw material since the lower the moisture content of the raw material, the more fragile the material becomes and the grinding is more effective [5].
Products intended for consumption have a well-defined grain size and an acceptable content of microorganisms which may take the vegetative, resting spore and spore form. The specified acceptable number of 5×10^2 microorganisms per 1 g of product is reached during the sterilization process [6]. Different methods of sterilization are known, e.g. by means of dry hot air, pressurized water vapor, UV radiation, ionizing radiation, gases and chemicals. Each type of sterilization has its own conditions and its replacement is not always possible.
Dry hot air can be used for both drying and sterilization. The drawback of this process is the extended penetration time, i.e. the time of achieving the assumed temperature in the raw material and the time of proper sterilization at this temperature. Besides low process efficiency, there is a concern about oxidation of the raw material and thus the loss of some fiber characteristics. UV radiation does not penetrate the raw material and, therefore, is not effective. However, during long-term exposure it may be harmful to personnel. Ionizing radiation is most commonly used for the sterilization of medical devices [7, 8].
Effective sterilization of the raw material can be done by means of superheated pressurized steam, typically at 150-250°C. Key factors include material soaking time throughout its entire mass, sterilization time and cooldown time. Ultimate moisture content of the raw material is an additional parameter. The sterilization process with superheated steam requires the equipment to be adapted to a given product to ensure the desired moisture content and the maximum acceptable level of microorganisms are obtained.

2. TEST STAND

In order to determine the process parameters, a test stand was designed and developed. CAD 3D SolidWorks [9, 10] was used for this purpose. The stand makes it possible to record the sterilization process parameters. The selected concept allows for adjustment of the temperature inside the main unit, reading the temperature of the sterilized raw material in different parts of the stand (top, middle, bottom), and for reading the pressure. Figure 1 shows a unit equipped with nozzles for the connection of temperature sensors, pressure gauge and valves for supplying steam, releasing steam and safety.

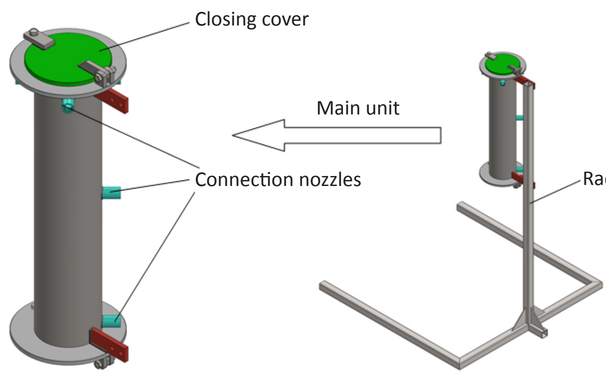

Figure 1 Diagram of the stand for testing the sterilization process of food raw materials

The stand is equipped with two 1000 W micanite band heaters. Temperature sensors with measuring elements located in the centre of the vessel, are installed in the bottom, middle and top of the stand. This solution enabled to read the actual temperature of the tested raw material. The stand is insulated with mineral wool to minimize heat losses (Fig. 2).
Plastic O-rings with a resistance of up to 300°C were used to seal the covers. During the tests, they withstood the pressure of 0.4 MPa. The layout of the temperature sensors is shown in Figure 3.

Figure 2 Testing stand with instrumentation

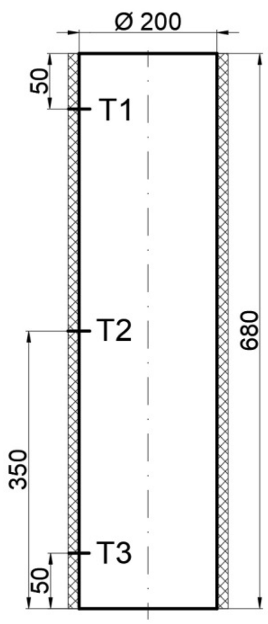

Figure 3 Layout of the temperature sensors: T1, T2, T3

The stand was tested upon equipping with the instrumentation. The sensors were calibrated and possible settings at which the sterilization process takes place were determined. It has been assumed that the raw material for sterilization has to be heated inside the vessel above 100°C. Then superheated steam at a temperature of 150°C to 250°C was applied (it was the main sterilizing medium). The valves responsible for steam supply and discharge were activated manually by the operator.

3. TEST RESULTS AND DISCUSSION

The number of micro-organisms, yeasts and molds in the raw material (cocoa shell) were initially determined. The results obtained are presented in Table 1.

Table 1 Parameters of raw materials to be tested

Sample name	Moisture content [%]	Quantity of microorganisms in 1 g of material	Quantity of yeasts and molds in 1 g of material
Cocoa shell	9.23	22 000	290

The permissible values for the total quantity of microorganisms, including yeasts and molds, were exceeded. In such a state, the product cannot be approved for sale.

By knowing the characteristics of the raw material, the test parameters were determined [11, 12]. Experimentally, it was established that at 200°C the raw material is not subject to excessive burning. Its color slightly darkens, but it does not have a negative effect on the product itself. Figure 3 shows the difference between the heat treated product (2 min) at 300 and 200°C.

Figure 4 Heat treated cocoa shell (heat treatment time: 2 min). Left side: 300°C, right side: 200°C

Sterilization trials were carried out to evaluate the effectiveness of the process. The test parameters are provided in Table 2. Sterilization time was 4 min. For the first 2 minutes, the material was heat treated. For the next two minutes, the superheated steam was supplied at the temperature indicated in Table 2.

Table 2 Parameters of sterilization process tests

Sample name	Heat treatment temperature [°C]	Steam temperature [°C]	Heat treatment time [min]	Sterilization time [min]
Pr_1	200	150	2	2
Pr_2	200	200	2	2
Pr_3	200	250	2	2

Table 3 Results of sterilization of cocoa shell

Sample name	Moisture content before sterilization [%]	Moisture content after sterilization [%]	Quantity of microorganisms in 1 g of material [average]	Quantity of yeasts and molds in 1 g of material [average]
Pr_1	9.23	4.72	530	130
Pr_2	9.23	4.85	290	<10
Pr_3	3.23	3.26	<10	<10

The results for the total quantity of microorganisms, yeast and molds are shown in Table 3.
The obtained results indicate that sample No 3 ensures the effectiveness of the sterilization process and its moisture content contributes to efficient grinding during micronization. Based on the obtained results, we can forecast the effectiveness of the process depending on the steam temperature. The stand designed allows for the determination of optimum process parameters.

4. CONCLUSIONS

Microbiological safety for raw materials used in the food industry is an essential factor. The designed stand is intended for the examination of various parameter settings (heat treatment temperature, superheated steam temperature, sterilization time) responsible for the effectiveness of the sterilization process.
The test carried out shows that the sterilization of cocoa shell will ensure microbiological safety when:
• the raw material heat treatment time will be 2 minutes and the heat treatment temperature will not be less than 200°C;
• the superheated steam temperature will be 250°C and the duration of its action will be 2 minutes.

Conflict of interest: The authors do not raise any conflict of interest.

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