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Sustainable Energy
in Food Production

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Developing the sterilization regimes of the canned food. Increasing energy efficiency

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Sterilized Canned Foods

- Sterilized canned food – a product hermetically sealed in the can (made of tin, aluminum or plastic) and sterilized.
- Canned foods are very popular in some countries, especially in Russia.

Canned Foods: Advantages

- Easy and long storage
- Sterility (no microorganisms)
- Ready-to-use
- Specific taste
- No preserving agents needed
- Possibility of making strategic reserves
- Fair profitability (very sensitive to cost of every procedure and to demand)

Canned Foods: disadvantages

- Part of vitamins and amino acids are destroyed
- Slightly rough texture
- Special care during processing
- High energy consumption

Thermal sterilization

- A process of destroying almost all of microorganisms at the temperature 100 °C or higher
- First inventor is Nicolas Appert (1804-1810), won the prize from Napoleon.
- The process was explained by Louis Pasteur (together with pasteurization)

Ways of Producing the Sterilized Canned Foods

- classic way (sterilizing the products hermetically packaged in the can) – suit for any product
- aseptic canning (the product and the cans are sterilized separately, and then the packaging process takes place in the aseptic zone) – suit for liquid products and some pastes.

Classification: Sterility Level

- Non-sterilized canned foods
- Pasteurized canned foods and semi-sterilized canned foods (vegetative forms of microorganisms are destroyed, spores still alive).
- Canned foods sterilized by ¾ (F=0,6-0,8)
- Fully sterilized canned foods with commercial sterility achieved (most spores are destroyed, but a few spores of non-pathogenic microorganisms which can't spoil the product, such as *Bacillus Subtilis*, at the common storage temperature may survive); F=4-6.
- Canned foods for tropic countries (F=12-15), can be stored at 40°C for a year.
- Absolutely sterilized canned foods (no survived spores allowed anyway). Used for a baby food and for strategic reserves.

Classification: Raw Material Source

- Canned fruit and vegetables
- Canned meat
- Canned dairy products
- **Canned fish products**
- **Canned marine products**

Canned fish

- Natural
- Natural with oil addition
- In sauces or filling (with or without PHT)
- In oil (with or without PHT)
- With vegetable addition
- Pastes
- Canned fish liver, milt, caviar
- Vegetable with fish addition

Classification: by purpose

- Common
- Baby food
- Youth
- For elderly
- For special purposes
- Delicacy
- Dietary and therapeutic
- Animal food

Canned fish: common technology

- Storage
- Defrostation
- Washing
- Gutting+Washing
- [Salting]
- Portioning

Preliminary Heat Treatment (if present)

Purposes:

- Increases relative food value
- Regulates water content
- Destroys microflora partially

Ways

- Blanching (with steam, hot water, oil, MW, IR)
- Frying
- Drying, smoking

Special operations

- Preparing the cans (washing) and the caps (marking)
- Filling the cans
- Exhaustion
- Sealing the cans
- Washing the cans
- Inspecting
- Filling the sterilizer (autoclave), cart or baskets

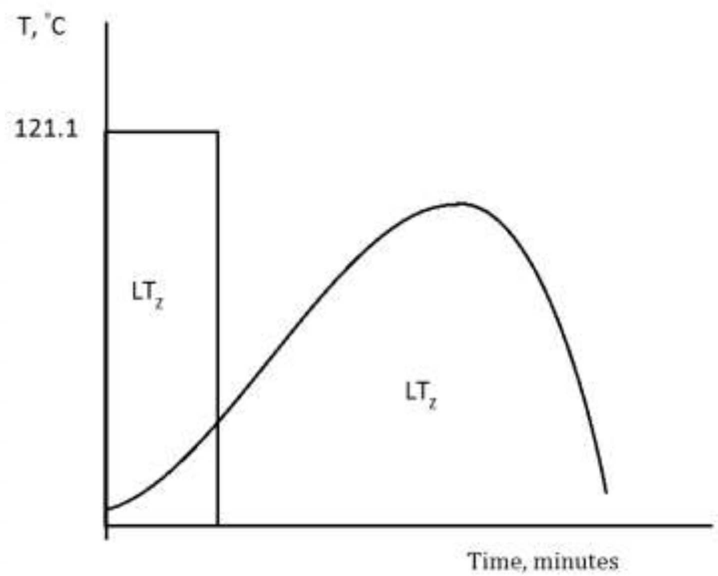
Thermal sterilization

- Main task – to destroy the spores of microorganisms
- Different temperatures of sterilization with the same action on the microorganism
- 8 hours at 100 °C ≈ 3,5 minutes at 120 °C – to destroy *Clostridium botulinum* spores
- Extra sterilization decreases the quality (overcooked, vitamins and amino acid destroyed, poorly digested), increases the energy needed
- Low sterilization can result in spore survival, diseases and possible death of the consumers
- In **no case** canned food may contain alive spores of the **pathogenic** microorganisms: *Cl. botulinum*, *Cl. perfringens, Bac. cereus. Paenibacillus polymyxa* is also disallowed.

Thermal sterilization: theory (after Bigelow)

- Sterilization effect (practical lethality) – the time of the theoretical process at the base temperature (121.1 °C = 250 °F) which is equivalent of the real process in the nonstationary thermal field.

[relative minutes]



Recalculating the temperature

- While the temperature is constant, it is easy to recalculate time at real temperature to the base temperature:

$$LT_Z = \frac{U}{10^{\frac{T_B - T_C}{z}}}$$

- where LT_Z – practical lethality of the process (rel.min)
  - U – time of the real process at T_C.
  - T_C - current temperature
  - T_B – base temperature
  - z - thermal stability constant (how degrees to increase the temperature to decrease duration of the process 10 times).

Recalculating the temperature (practical)

- In nonstationary thermal field:

$$LT_Z = \int_0^{\tau_P} \frac{d\tau}{10^{\frac{T_B - T(\tau)}{z}}}$$

- Numeric integration is needed to evaluate it

$$K_{Ti} = \frac{1}{10^{\frac{T_B - T_{Ci}}{z}}}$$

$$LT_Z = \int_0^{\tau_P} \frac{d\tau}{10^{\frac{T_B - T(\tau)}{z}}} \approx \sum_{i=1}^{n} K_{Ti} \cdot \tau_i$$

Determining LT_Z (practice)

- Obtaining temperature in the less-heated point of the less-heated can.

Two ways:

- wired online (sensor is placed in the can, wire is passed through **specially modified sterilizer** to the data processing system)
- Wireless offline (for example, Ellab A/S, Denmark) – sensor is connected with simple data collecting system working at the sterilization temperature.

Normative sterilization effect

$$F_N = D_T \cdot (\lg B + a)$$

- where B – initial quantity of spores
- a – order of spores destruction (the probability of spore survived in a single can is 10^{-a})
- x – coefficient for non-logarithmic effects
- D_T - thermal stability constant (duration of decreasing microorganism quantity 10 times) at temperature T.

- $LT_Z = F_N$ is enough to give the warranty of practical sterility.

Determining normative sterilization effect

- Inoculating cans with the test sporogenic microorganism (*Cl. sporogenes, Bac. subtilis, Cl. botulinum*).
- Sterilizing at 121.1 °C; microbial test.
- Sterilizing at different temperatures, microbial tests
- Calculating D

Ways of improving the sterilization process

- Decreasing LT_Z *(not less than* F_N*)*
- Thorough temperature control
- Thorough microbiological control of raw materials and all semi-products to prevent microbial invasion.

This results in better sensory characteristics, better biological value, less energy consumption (water, steam, electricity)

Ways of thermal sterilization

- With steam with air backpressure with water-chilling
- In water with steam heating with water backpressure with water-chilling
- With steam without backpressure

Sterilization formula

$$\frac{a - A - B - C}{T}; P$$

- a – blowing up time (for steam sterilization only)
- A – heating time (from somewhat less 100 °C up to T)
- B – sterilization time (at T)
- C – chilling time
- T – temperature of sterilization
- P – backpressure (bar or MPa)

Final processes

- Cans washing, drying (wiping)
- [Cans labeling]
- Packaging, labelling
- Maturing/storage
- Inspecting

Ways of improving energy efficiency

- Microbiological researches to get the correct F_N.
- Decreasing LT_Z as close to F_N as possible.
- Avoiding energy losses in sterilizer.
- If using PHT, partial destroying of microorganisms should be taken into account.
- Using modern automatic systems to avoid overheating, overregulation etc.
- Using effective equipment adequate to the throughput of the canning line.