Preservation of Food by Means of Heat Treatment

(Sterilisation, Pasteurisation)

Introduction

The preservation of food by heat treatment (sterilisation, pasteurisation) has been a relatively long-standing method and is widely used both in industry and households. In this procedure the foodstuffs are packed (glasses, tins, plastic bags) and submitted to heat treatment after having been prepared accordingly before (peeling, cutting etc.) and after an eventual pre-treatment.

It is the principal aim of the heat treatment to partly or entirely inactivate any microorganism in foodstuffs. By this procedure, spoilage or pathogenic microorganism are inactivated or killed. Thus, the product assumes a certain durability, with the hygienic quality being fully guaranteed.

Among the side effects of heat treatment - these can be, however, of importance in some cases - there are the inactivation of enzymes in food and the change of its texture and consistency (cooking).

1. Sterilisation

The sterilisation aims at the complete inactivation of all germs, i. e. both vegetative germs and spores. For sterilisation several different temperature-/time-combinations are applied, according to the type of food and equipment. Temperatures vary between abt. 115° and 140° centigrade. If high temperatures above 130 degrees centigrade and accordingly short sterilisation times (in extreme cases just some seconds) are applied, one speaks of the so-called HTST (high temperature short time) procedure.

Sterilisation of foodstuffs with a pH-value more than 4.5 is carried out according to the 12-D-concept and is aimed at the most dangerous pathogenic microorganisms, called clostridium botulinum. For this type of microorganism, an anaerobic sporeforming microorganism, the F-value at 121° centigrade is approximately 2.5 min; for safety reasons one applies normally 3 minutes. This means that a foodstuff has to be heated, at the slowest heating point, up to 121.1° centigrade for at least 3 minutes, or a different temperature/-time-combination, to make sure clostridium botulinum is inactivated (botulinus cook).

As far as tropical tinned foods are concerned, the sterilization process is aimed at the highly heat-resistant and thermophilic germ called bacillus stearothermophilus. From a D-value of 4.5 minutes at 121.1° centigrade and a reduction by 4 ten's powers regarding heat treatment results an F-value of 18.0 min.
The spores of bac. stearothermophilus are, however, no longer able to germinate at a pH-value of less than 5.3.

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Foodstuffs with a pH-value of less than 4.5 need not be heated as much as that due to the fact that at a pH < 4.5 the spores of clostridium botulinum do not germinate and no toxins are produced. For such sour foodstuffs pasteurisation will be applied.

2. Pasteurisation

Pasteurisation only inactivates the vegetative germs, but not the spores. It is an important purpose of pasteurisation to inactivate pathogenic, i. e. toxin-producing germs. According to the type of foodstuff, purposes and conditions (temperature/time) can, however, be very different. The temperature will range, in most cases, between 60° and 100° centigrade. The application of higher temperatures is often impossible because of organoleptic quality.

Pasteurisation can also be defined as a heating process in which a foodstuff is exposed to a lethal effect of less than F = 3 min. at 121° C. In general, pasteurisation aims at a reduction in the number of germs of at least 6 ten's powers.

The pasteurisation follows the same regularities as the sterilization (D-value, z-value). Analogously to the F-value in the sterilization, the P-value is applied in the pasteurisation. This latter value is referred, like the F-value, to a certain reference temperature and the z-value of the target organism.

The inactivating effect of a pasteurisation process is calculated, like in the sterilization, over the summation of the rates of lethality per minute. This rate of lethality can be worked out mathematically:

$$P = 10^{\frac{T-Tx}{z}} \qquad <4>$$

or expressed or any time interval you choose:

$$P = 10^{\frac{T-Tx}{z}} \times t \qquad <5>$$

P = Lethal effect of pasteurisation (min)

T = Pasteurisation temperature (degrees centigrade)

Tx = Reference temperature (degrees centigrade)

z = z-value of a given type of microorganism

t = Time of heat treatment at a given temperature (min)

As reference temperature one often uses that of 93,3° centigrade or 200° F (z = 8.9° centigrade or 16° F).

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Pasteurisation of foodstuffs is applied in cases where a partial inactivation of existing microorganism is sufficient. In addition to pasteurisation there are still other preserving methods frequently applied:

- Acidifying (e. g. Acidifying of vegetables with subsequent pasteurisation)
- Cooling (e. g. pasteurisation of milk with subsequent cooling)
- Salting
- Gassing

Therefore, the preserving effect of pasteurisation depends to a certain extent on the accurate execution of the other measures. If, for example, a vegetable salad is acidified with vinegar, it is important the acidification is going on homogenuously. Otherwise it might occur that parts of the salad with a higher pH-value perish which would affect the whole product. It is possible that in certain foodstuffs, due to the heat treatment or during the period of durability, the pH-value might go up which could upset the microbiological stability of the product in the long run.

3. Sous vide - a new procedure

As far as the "sous-vide method" goes, foodstuffs are first prepared in the normal way for the kitchen (cleaning, peeling, cutting, frying of meat). The food is then vacuum-packed in heat-resistant plastic foils and cooked under controlled temperature/time conditions. After cooking the products are cooled down as soon as possible and cold-stored until consumption by the end user. For the preparation by the end user the products are warmed up again, mostly in their package.

This procedure originally developed by a French cook pursues two aims:

- By cooking in a sealed bag at a low temperature one achieves a better quality as against normal cooking. This is especially evident in meat (juiciness, tenderness).
- From the procedure results an durability of 6 to 21 days, but only with strict cold-storage. The durability allows a certain flexibility in the distribution of "sous-vide" products.

The "sous-vide procedure" has been subject of intensive microbiological research during the last few years. For it appears to be essential for a sufficient microbiological stability that hygienic principles are strictly observed throughout the production process:

- Use of clean, if possible low-germ raw material
- Controlled cooking conditions (temperature, time)
- Fast cooling down after cooking as well as cold chain regarding storage and transport/distribution.

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As far as the cooking process is concerned, various indications are given for heating. The most important microorganisms to be considered are, besides bacilli and lactobacilli, the psychotrophic strains of clostridium botulinum, type B and E. These strains have to be reduced in the cooking process by at least 6 ten's powers. For that a P-value of 40 min at 70° centigrade and a z-value of 10° centigrade is indicated. Or, in other words, at the slowest heating point of the foodstuff 90° C during 7 minutes (better during 10 minutes) are to be reached. The latter indication (90° C during 10 minutes) corresponds to the French regulations. As results from the above described, the cooking process should largely correspond to a pasteurisation.

With a pasteurisation at 90° C min. it is normally possible to reach a keeping quality of more than 10 days at refrigerating temperature. In case of shorter cooking times the period of durability will be accordingly reduced. According to the required durability, the total p-value to be reached during the cooking process will vary.

It appears to be a matter of fact that many "sous-vide factories" are confronted with microbiological problems, because they fail to observe the above formulated hygienic principles.

For an unobjectionable production it is important the packing material meets the following requirements:

- tear-resistant
- easy to seal
- of neutral taste or low migration of monomeres from the packing material into the foodstuff
- low oxygen permeability
- heat-resistant

In addition to cooking, it's the speed of the subsequent cooling and the strict keeping of the refrigeration temperature that are of essential importance. In order to avoid the growing of the psychotrophic strains of clostridium botulinum, a refrigeration temperature of below 2° C or 3° C is recommended.

For the cooking of "sous-vide products" on industrial level the following devices and equipment come into question:

- Lying autoclaves (similar to DORNOW/Neuweiler-autoclave), cooking of the foodstuffs by means of an air-steam-mixture. Overpressure to avoid the tear of packages.

- Lying autoclaves (similar to DORNOW/Neuweiler-autoclave), cooking of the foodstuffs by means of water sprinkling, build-up of counterpressure to avoid the tear of packages.

- Autoclaves completely filled with water, product immersed in water bath, with the autoclave being fed via two storage vessels wit hot water or ice water, respectively.

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