

Method for the Surface-Pasteurization and -Sterilization of Pieces of Food

The invention relates to a method for the surface pasteurization or surface sterilization of pieces of food products, in particular oleaginous seeds, such as almonds, hazelnuts, pecans, walnuts, as well as peanuts, bran, cereals, coffee, cocoa and the like.

By nature, agricultural products and foods are loaded with harmless and potentially pathogenic micro-organisms. In most cases, agricultural products are processed fresh, or are made durable with the aid of suitable technological means. Among industrially employed preservation methods are counted, inter alia, sterilization or pasteurization by means of heat, irradiation with ionizing rays, or also gassing with lethally-acting gases. The two last-mentioned methods in particular can only be employed in a limited manner, since the use of these methods is strictly regulated by law.

Lately, several cases of contamination of raw almonds with salmonella have been reported. For increasing the safety of almond products, the U.S. authorities have ordered that, starting in autumn of 2007, the entire almond harvest is to be pasteurized or to be heat-treated to a sufficient degree. The pasteurization of almonds and other oleaginous seeds makes special demands on the methods to be used. The water content of the almonds is not allowed to be increased to an appreciable degree by and during the treatment, because both the storage capability and the integrity of the almonds are harmed by this. Moreover, raw almonds tend to lose the skin around the seed, which must be considered to be a serious loss of quality.

For this reason a heat-deactivation method is being

presented here, which is suitable to considerably reduce the microbial surface contamination of almonds, oleaginous seeds and other pieces of food having a medium or low water content without changing the qualitative properties of the products (water content, appearance, aroma and taste, texture). In accordance with the regulations of the U.S. authorities, in the case of raw almonds it is possible to speak of a pasteurization in connection with a reduction of the micro-flora by 5 log-units.

Efficient heat-deactivation of micro-organisms is achieved in an atmosphere with increased water activity. In contrast thereto, micro-organisms are only reduced to a small extent by dry heating. For this reason heat-pasteurization and -sterilization methods employed on an industrial scale require a large water content of the products. This relates in particular to sterilization and pasteurization methods employed in the preserved food and beverage industries, or for preserving milk and milk products.

Above all, pasteurization or sterilization is problematic in connection with pieces of products showing a low water activity of less than 0.8 and which, in case of a heat treatment, cannot be subjected to a greater water content. This applies in particular to almonds, nuts and other oleaginous seeds, but also to spices and other pieces of food products. The treatment of raw, unblanched almonds in particular is difficult since, on the one hand, changes in aroma and color progress rapidly in the course of a heat treatment in an moist atmosphere and, on the other, a release of the skin around the seed, such as is provoked by the application of water, must be absolutely avoided. It is thus possible to consider the pasteurization of raw almonds as an example of a demanding material for pasteurization.

For example, methods are employed for the heat-deactivation of dry spices, in which the spices are charged for a short time with saturated or super-saturated steam in a pressure chamber, and the pressure is subsequently released (Gysel, 1990). The sudden pressure release leads to a separation of micro-organisms from the surface and to the bursting of bacterial cells. The joint action of moist heat and a mechanically-acting pressure-release process leads to directed and rapid deactivation of micro-organisms.

However, methods operating in accordance with this principle are not suited to the surface pasteurization of almonds and other oleaginous seeds. On the one hand, the water content is greatly increased by the application of saturated or superheated steam at a pressure of > 1 bar (temperatures above 100°C) because of the occurring condensation. This considerable water intake, such as arises from such treatment, makes subsequent drying necessary and leads to a reduction of the quality and the shelf-life of the products. On the other hand, the integrity of the products is damaged, in particular because of the retention of a large proportion of surface water and because of the occurring mechanical forces in the course of the pressure relaxation. In the case of raw almonds or other not blanched, in particular oleaginous seeds, the skin comes off, which is detrimental to quality.

The CFP Power Pasteurization System of the Ventilex Company (West Chester, OH) is explained on the website www.nutpasteurization.net and was especially developed for the pasteurization of almonds. This method consists of a continually conveying fluid chamber, into which the almonds are placed and are treated under overpressure with superheated steam. Subsequently the nuts are dried in a further, also continuously-conveying

chamber by warm air and are then cooled. Because of the enormous condensation during the treatment, the Ventilex method increases the water content of the almonds to a considerable extent from approximately 5% up to 10%, which impairs the quality of the pasteurized almonds to a substantial degree and leads to the detachment of parts of the skin during subsequent hot-air drying.

Moreover, the high treatment temperatures lead to undesired changes in the color and aroma of the almonds.

In accordance with the JSP-I Jet Stream® Almond Surface Pasteurization System of the firm FMC Technologies (Sandusky, OH), almonds are heated to a preset temperature by means of steam; the almonds are then subsequently pasteurized in moist air.

Pasteurization takes place in a continuous chamber in moist air, wherein the dewpoint temperature of the air is considerably higher than the temperature of the introduced almonds (Gunawardena and Weng, 2006). The moist air condenses on the almond surface which, together with the effect of the heat, leads to the desired deactivation of micro-organisms. This method, too, leads to a large amount of water condensation, so that subsequently to the pasteurization the water must be dried off by means of hot air. As a result, the almond quality is greatly impaired by the large absorption of water during heating with steam and pasteurization in moist air, as well as subsequent drying.

Clark (2007) has described further modifications of steam-treating methods. The Safesteril method of the ETIA company, F-Compiègne (Antonini, 1993) is a continuous method for the treatment of pieces of goods and powders with steam. Here, a product flow is transported by means of a heated screw through a closed chamber and is charged with steam in it. Since this treatment takes place at normal pressure, steam is condensed out

until the material has reached a temperature of 100°C. Here, heating the product by means of the screw is intended to prevent an excessive condensation of steam on the product, which in the end is a function of the heat introduction via the heated screw. Because of the mechanical action by means of the screw transport, but mainly because of the distinctive water introduction, this method is not suitable for the heat treatment of raw almonds and oleaginous seeds.

Further methods employ a saturated steam atmosphere under reduced pressure. Kozempel et al. (2003) describes a vacuum-steam-vacuum method for pasteurizing food surfaces. In the process, the pieces of material are alternately subjected to a vacuum and charged with steam. By the alternating application of vacuum and steam it is intended to assure that the condensation reaches all pore openings and depressions in the surface.

The method of Steam Lab Systems (CH-Bottmingen) (Blaha, 2003) represents a method derived from this. With this method the product is subjected as described to a cycle of vacuum and steam treatment. The introduction of water vapor following a vacuum step takes place until atmospheric pressure has been reached. On the basis of the varying pressure conditions it must be assumed that water vapor condenses until normal pressure conditions have been reached, which again leads to a relevant absorption of water.

In addition, the temperature conditions, such as prevail on the surface in the course of the process, are insufficiently defined, which is also detrimental to the safety of the process.

Thus, all pasteurization methods for almonds and other piece-sized goods known and described here have in common

■ that the treatment is performed in a moist atmosphere under normal or overpressure conditions or, respectively in the

case of the vacuum methods, until the occurrence of normal pressure conditions; it can therefore be assumed that with the complete provision of an equilibrium the surface temperature is 100° C or more; in this case reactions which negatively affect product quality proceed very rapidly;

■ that, based on the intentional heat introduction they lead, because of condensation, to a significant increase of the water content of more than 2%; a (temporary) increase of the water content in the said amount is very detrimental to the quality of the pasteurized product, since cooking aromas are developed and the surface structures, such as the skins of almonds, for example, disintegrate and are destroyed;

■ that, because of the large absorption of water, hot air drying becomes necessary; in the course of drying in hot air degenerative changes occur, such as browning reactions, from which a relevant loss of quality and a considerable loss of authenticity of the product results;

■ that the pasteurization conditions can only be insufficiently reproduced, since the surface temperature remains constant only after reaching the equilibrium temperature (100°C under normal conditions); the absence of constant pressure conditions leads to inaccurately defined pasteurization conditions on a product surface.

It is therefore the object of the invention to create a method of the type mentioned at the outset with which the water absorption and the qualitative changes of the food products are minimized and the pasteurization or sterilization conditions are optimized.

In accordance with the invention this is achieved in that the food products are employed after having been pre-warmed,

wherein the product temperature is selected to lie a few degrees below the evaporation temperature of the pasteurization or sterilization systems, that the pre-warming temperature of the food products is selected to be lower than the saturation temperature, preferably a few degrees below the saturated steam temperature at the preset pressure, that treatment is performed in a moist atmosphere free of air, wherein pasteurization is performed at temperatures between 55 and 99°C at low pasteurization pressure, or sterilization at temperatures between 100°C and 140°C at a higher sterilization pressure, that the heat treatment is performed in the course of 1 to 30 min, and that the condensation water is removed from the surface of the food products by means of subsequent vacuum drying under further reduced pressure.

The novel method consists of three steps:

- 1) preheating the food products,
- 2) pasteurization or sterilization in a pure steam atmosphere, wherein the surface temperature corresponds to the evaporation temperature at the system pressure set,
- 3) drying of the surface condensation water under vacuum.

So that all other pieces of food products, such as nuts, oleaginous seeds, grains, spices and the like can be optimally pasteurized or sterilized, the following basic rules should be observed:

1. To reduce losses in quality, it is necessary to optimally select and adjust the surface pasteurization or sterilization temperature. By means of matching the system pressure it is possible to set the evaporation temperature, and thereby the condensation temperature, in a directed and reproducible manner. The system pressure can be maintained

constant in a range between 0.15 to 4.0 bar, by means of which it is possible to realize pasteurization temperatures of 55 to 99°C and sterilization temperatures of 100°C to 140°C.

2. Since the water absorption and subsequent drying definitely contribute to the reduction of quality of the food products, an unnecessary or excessive absorption of water is avoided. This is achieved in that the food products are intentionally pre-warmed by 0 to 8°C below the evaporation temperature. By means of this it is possible to limit the water absorption required for warming to less than 0.5%, which makes subsequent hot air drying superfluous.

3. A small remaining amount of water present on the surface can be removed in a short time by reducing the system pressure. Moreover, the food products are immediately cooled by the evaporation of surface water, so that the action of the heat can be rapidly terminated.

The basic rules are followed by the characteristics detailed in the dependent claims in that they are observed during the three method steps.

1. Pre-warming

Pre-warming of the food products takes place preferably in an apparatus in which the food products are rapidly warmed to the intended temperature for preventing the premature removal of water. For example, pre-warming can take place in a continuous infrared drum by means of hot air or microwaves. The method also does not exclude pre-warming by other energy transmission possibilities. The pre-warming step is used for conditioning the food products and at best makes a negligible contribution to the deactivation of micro-organisms on the surface of the material. The pre-warming temperature is selected to be such that during the

subsequent steam treatment the evaporation temperature is 0 to 8°C higher than the pre-warming temperature. By means of this it is possible to avoid an excessive condensation of water vapor on the product surface and an excessive water absorption by the food products during the subsequent steam treatment. Thus, the pre-warming temperature can lie in the range between 50 to 144°C. The range between 55 and 99°C can preferably be selected for pasteurization, and the range between 100 to 140°C for sterilization. For pasteurizing almonds, the pre-warming temperature preferably lies between 70°C and 90°C.

2. Pasteurization in a Steam Atmosphere

Heat deactivation (pasteurization or sterilization) takes place at temperatures between 50 and 140°C. Customarily only pasteurization is achieved with treatments below 100°C, while temperatures up to 144°C must be reached for sterilization (complete deactivation even of thermostable endospores). In this case the treatment temperature is determined by the steam pressure prevailing or set in the system. With treatment temperatures below 100°C, the system pressure becomes less, at treatment temperatures above 100°C greater, than the atmospheric pressure.

System pressures below atmospheric pressure are realized in that the pressure in the treatment chamber is reduced by means of a vacuum pump. As soon as the set system pressure falls below the set value, the steam supply valve opens and steam supply is started. Steam supply takes place via a regulating valve, which maintains the system pressure in the treatment chamber constant. For example, the treatment of almonds takes place at an absolute pressure of 0.1 to 0.95 bar, preferably at 0.2 to 0.8 bar.

After filling, the product temperature lies 0 to 8°C below the evaporation temperature of the system. The temperature of the

material rapidly rises to the evaporation temperature because of the condensation of small amounts of water. Then water can no longer condense on the product surface; the system is in equilibrium. As a function of the steam saturation temperature, the amount of time (1 to 30 min) of heat application must be selected in such a way that a sufficient deactivation of the micro-organisms is achieved.

3. Removal of Surface Water

At the end of the treatment the steam supply is shut off, while the vacuum pump continues to run. By means of the further reduction of the system pressure to between 0.15 to 0.01 bar (absolute pressure), the amount of water picked up because of the temperature equalization can be dried off again in a short length of time of 2 to 20 min, so that the pasteurized sterilized food products do not show an increase in water content.

The invention will now be explained in greater detail by means of an exemplary embodiment. Shown are in:

Fig. 1, a device for the surface pasteurization of pieces of food in accordance with the CCP method in accordance with the invention, and

Fig. 2, survival curve and log-reduction of *Enterococcus faecium* on almonds pasteurized in accordance with the CCP method at 81.4°C (system pressure 0.5 bar).

The method here described is for example performed in a device as represented in Fig. 1. The food product, which has been pre-warmed to a predetermined temperature by means of a suitable method is presented in a pre-container 1. By opening a flap 4, the food product is filled into a pressure chamber 2. The pressure chamber 2 is provided with a double shell, and by means of steam the shell is maintained at a pre-selected temperature

corresponding to the selected conditions. After the filled pressure container has been closed in a pressure-tight manner, the pressure is reduced by means of a vacuum pump 7. Once the preselected pressure has been reached, a steam valve 6 is opened.

The admittance of steam is regulated by means of a regulator valve in such a way that the pressure in the chamber remains constant and corresponds to the preset conditions. Depending on the selected pressure, or respectively selected temperature, and a function of the product, the pasteurization/sterilization lasts 1 to 30 min. At the termination of the pasteurization/sterilization treatment the steam valve 6 is closed and the pressure in the container is reduced to between 0.15 to 0.01 bar. After a further 2 to 20 min, vacuum drying is finished. The container pressure is again matched to atmospheric pressure by means of a pressure equalization valve. A removal opening 5 is opened, and the food product is taken out. If desired, the removal of the food product can be aided by switching on a mixing spiral 3. Common process parameters for almonds, nuts and oleaginous seeds are represented in Table 1.

Under suitable circumstances, minimal water absorption results with this method on the surface, which can amount to less than 0.5%, depending on the selected pasteurization/sterilization conditions. Nevertheless, in the course of the treatment a moist atmosphere is formed around the food products. By means of this it is possible to assure that the treatment takes place in a sufficiently moist atmosphere close to a water activity of 1.0, so that a sufficient deactivation of vegetative micro-organisms and of endospores on the product surface takes place under suitable conditions (Fig. 2). The inherent quality of the food products, in particular in case of pasteurization, is maintained with this

process. Neither are aroma or color changes induced, nor can a loosening of the skin of almonds be observed at optimal parameters (s. Table 1).

The pasteurization and sterilization method here described is also suited for a thermal treatment of other oleaginous seeds, such as hazelnuts, pecans, walnuts, but also peanuts, bran, cereals, coffee, cocoa, etc. This method is also suitable for treating pulverulent materials, since the small amount of wetting and water absorption does not lead to the clumping of powder particles.

Table 1

Process parameters for the surface pasteurization of raw almonds inoculated with *Enterococcus faecium* NRRL-B2354. The initial contamination with *E. faecium* was 2×10^7 CFU/g.

Pre-warm Temp.	Abs. Pasteurization Pressure	Evap. Temp./Condensat. Temperature	React. Time	Vacuum Achieved	log-reduction
°C	bar	°C	Minutes	Minutes	
80	0.5	81.5	2	5	5.5
80	0.5	81.5	5	5	7.4
80	0.5	81.5	10	5	6.6
90	0.5	81.5	2	5	5.3
70	0.5	81.5	10	5	7.9

Bibliography

G. Antonini, O. Lepez, P. Sajet, D. LaPlace, 1993, "Method and Device for Reducing or Eliminating the Microbial Flora in an Agri-Foodstuff in the Divided Solid State", FR 2680637.

J. Blaine, 2003, "Verfahren zur Entkeimung von Produkten" [Method for Sterilizing Products], WO 03/037109 A1, 05/08/2003.

J.-P. Clark, 2007, "Thermal Processing of Foods", Food Technology 61 (04), 79-82.

R. M. Gunawardena, Z. Weng, 2006, "Dry Food Pasteurization Apparatus and Method", US 2006 040029.

M. M. Gysel, 1990, "Die Entkeimung von pflanzlichen Trockenprodukten mit Sattedampf" [Sterilization of Vegetable Dry Products with Saturated Steam], dissertation ETH No. 9203, Swiss Technical University ETH, Zürich.

M. Kozempel, N. Goldberg and J.C. Craig, 2003, "The Vacuum/Steam/Vacuum Process", Food Technology 57 (12), 30-33.

C l a i m s

1. A method for the surface pasteurization or surface sterilization of pieces of food products, in particular oleaginous seeds, such as almonds, hazelnuts, pecans, walnuts, as well as peanuts, bran, cereals, coffee, cocoa and the like, characterized in that

the food products are employed pre-warmed, and the product temperature lies a few degrees below the evaporation temperature of the pasteurization or sterilization systems, that the pre-warming temperature of the food products is selected to be lower than the saturation temperature, preferably a few degrees below the saturated steam temperature at the preset pressure, that treatment is performed in a moist atmosphere free of air, wherein pasteurization is performed at temperatures between 55 and 99°C at low pasteurization pressure, or sterilization at temperatures between 100°C and 140°C at a higher sterilization pressure, that heat treatment is performed in the course of 1 to 30 min, and that the condensation water is removed from the surface of the food products by means of subsequent vacuum drying under further reduced pressure.

2. The method in accordance with claim 1, characterized in that

the product temperature is selected to lie 0°C to 8°C below the evaporation temperature of the pasteurization or sterilization system.

3. The method in accordance with claim 1,

characterized in that the temperature difference between the pre-warming temperature of the food products and the saturated steam temperature at a given pressure is preferably selected to be 0°C to 8°C.