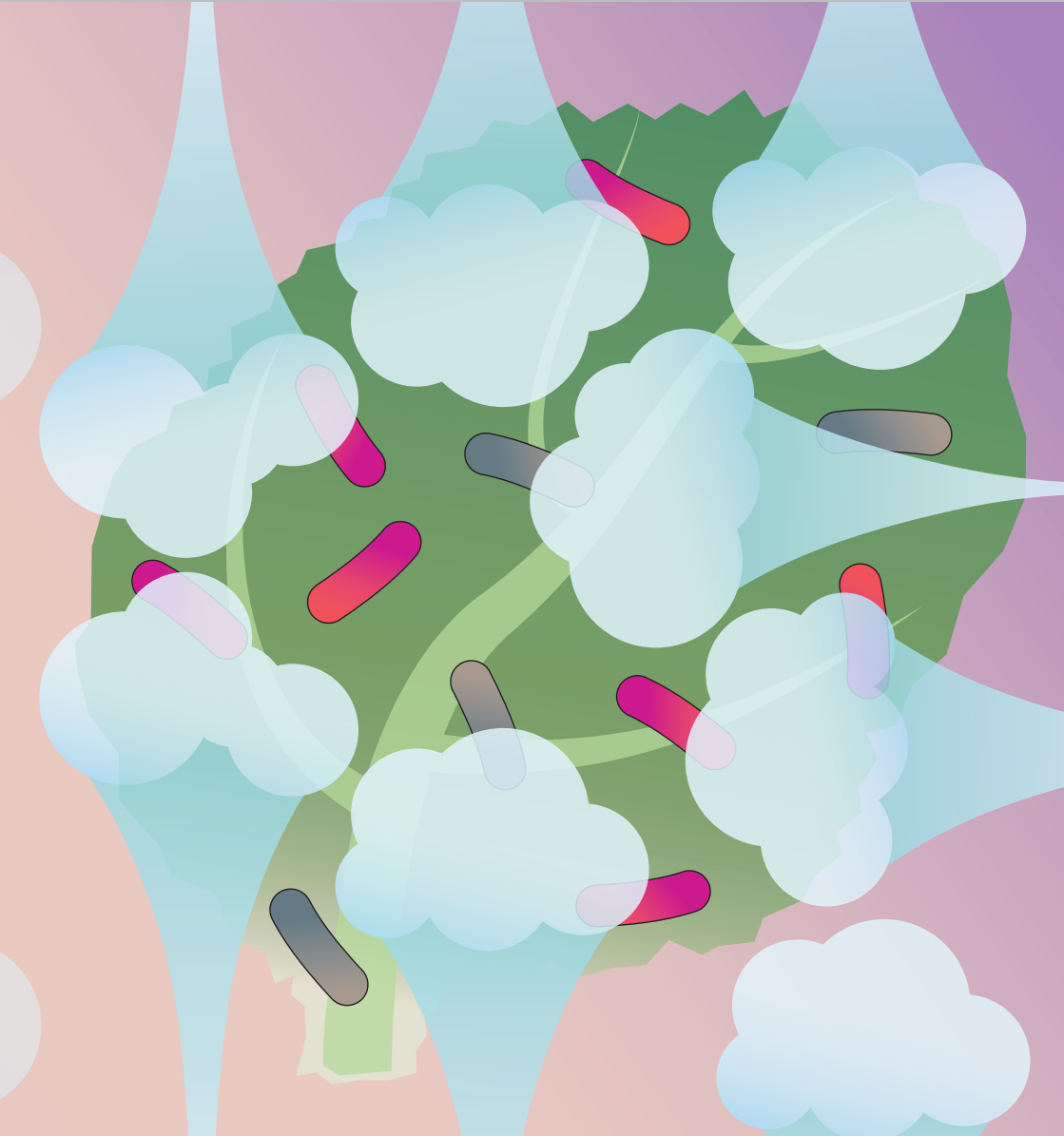




Good Food, Good Life

# Steaming of dried produce:

**Guidance to minimize the microbiological risk**



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## Purpose of this booklet

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### Content overview

This booklet helps you to understand and manage the critical elements that impact microbiological food safety during steaming of dried produce.

- Why is it important to manage the steaming properly;
- What are the main elements to control during steaming of dried produce;
- What are the main elements to manage for an effective maintenance of equipment;
- Why is it important to validate and verify the microbial reduction for a steaming process.

### Microbiological food safety for steaming of dried produce

Dried produce (e.g. herbs, spices, (root) vegetables, fruits) can be contaminated with pathogenic microorganisms that survive the drying process or contaminate the product at a later stage in the supply chain.

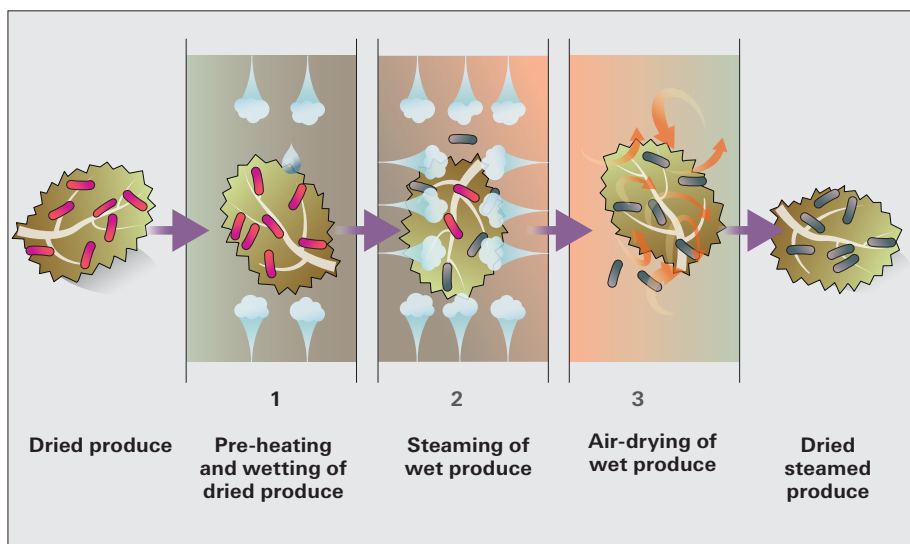
**For some dried produce categories, steaming is a frequently applied thermal process to control microbiological hazards (see decision tree on page 6 in booklet "Drying of produce: Guidance to minimize the microbiological risk")\*.**

On dried produce, pathogenic microorganisms do not grow but can survive and maintain pathogenicity for several months or even years. The microorganisms that are considered a relevant hazard for dried products are mainly *Salmonella* spp., Shiga Toxin Producing *Escherichia coli* (STEC) and *Listeria monocytogenes*. Pathogenic spore-forming microorganisms are usually not considered a hazard in dry products because the toxicity is linked only to vegetative cells that are generated after spore germination. Due to the low moisture present in dried products, spores do not germinate and vegetative cells are not formed.

\* see [www.nestle.com/aboutus/suppliers](http://www.nestle.com/aboutus/suppliers)

Inactivation of microorganisms in low moisture foods, such as dried produce, is very difficult to achieve due to the high heat resistance developed by microorganisms in dry environments. For this reason, steaming is a technology widely applied for the microbiological decontamination of dried products. It is comprised of three steps: pre-heating, steaming and air-drying (see below and section "Steaming" for more details). For some technological applications, the first two steps (pre-heating and steaming) can be combined.

**Although steaming of fresh produce, also known as blanching, is not in the primary scope of this booklet, process parameters of blanching are given in section "Validation" on page 11.**



## Field of application: Steaming of dried produce

For fresh produce processed with drying technologies that cannot be considered a control point for microbiological hazards (sun drying and freeze-drying)\*, an additional processing step should be identified. Steaming may potentially be applied as control measure.

For fresh produce processed with drying technologies that may be considered a control point for

microbiological hazards, the addition of steaming can potentially be applied if the inactivation achieved during drying is not sufficient to guarantee food safety.

The steaming step is generally applied after drying (see table below). However, to maximize energy efficiency and reduce quality loss on final products, blanching of fresh produce before drying instead of steaming after drying can be considered in some cases.

Technologies that cannot be considered control points for microbiological hazards	<b>Sun drying</b>		
	<b>Freeze-drying</b>		
Technologies that may be considered control points for microbiological hazards	<b>Convective air</b>		
	<b>Fluidized bed</b>		
	<b>Microwave (also with vacuum)</b>		

\* see decision tree on page 6 on booklet "Drying of produce: Guidance to minimize the microbiological risk"

# Steaming



## Process overview

The steaming of dried produce (herbs, spices, (root)vegetables and fruits) usually involves the use of saturated steam at temperatures between 95–130°C in a three-phase process: pre-heating, steaming and air-drying, as illustrated above (page 4). For some technological applications, pre-heating and steaming take place in the same processing unit.

The drawing below represents a schematic overview of the steaming process. Product temperature, steam temperature, steam pressure and residence time are the main parameters to control for a good management of the process.

Pre-heating is applied to wet the product surface through the condensation of steam and makes microorganisms more sensitive to heat. In addition to this, it is also used to heat the product to a temperature of about 80–90°C.

Steaming is the central part of the process where microbiological inactivation takes place. The choice of the temperature is based on the desired level of inactivation and the impact on product quality (see page 11).

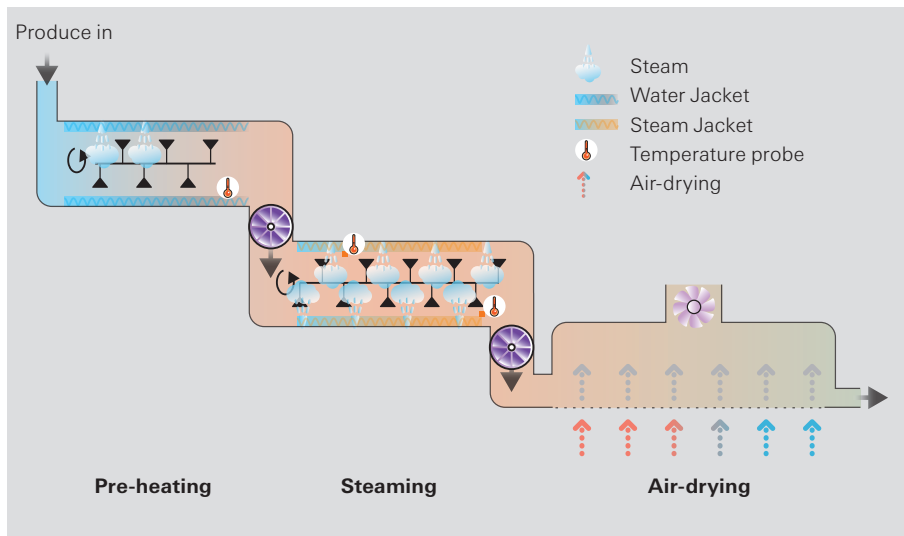
Air-drying is necessary to bring the product moisture back to the initial level and to cool the product down. It is usually done using convective hot and cold air in sequence.

## Management of the process

### ⚠ Why is it important to measure product temperature and steam pressure in continuous during steaming?

When saturated steam is applied, product temperature is the most direct indicator of microbiological inactivation. Thus, temperature should be continuously monitored and recorded during steaming. Probes can be used to monitor the temperature in different points of the product bulk (product batch mixed with air) along the steaming chamber. Steam pressure should also be continuously monitored, as it is an indirect measure of steam temperature, and thus an additional

control parameter for microbiological inactivation. To maintain overpressure in the steaming chamber two valves are present, one at the exit of the pre-heating and one at the exit of the steaming chamber, respectively. The continuous monitoring of the steam pressure is important to verify that the valves seal properly and no steam is leaking out of the chamber. Steam temperature and residence time should also be recorded.

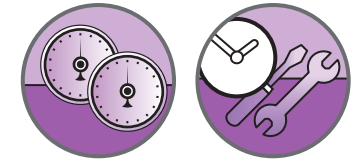


## Best processing practices



ACTIONS	RECOMMENDATIONS
Running of temperature profiling in the product bulk during commissioning	Process parameters must be considered for the worst processing conditions (e.g. the highest volume throughput, lowest temperature, shortest time, the beginning (start-up) and the end (shut-down) of the process). Temperature measurements should be done in different points of the machine using Recording Temperature Devices (RTD). Dataloggers can also be used if the machine design allows to do so. This will give a set of temperature lines. The lowest temperature line should be considered since it represents the worst temperature.
Continuous recording of product temperature, steam pressure and steam temperature during every production	Product temperature, steam pressure and steam temperature should be continuously recorded during production. Recording Temperature Devices (RTD) and pressure measurement devices should be fitted in the steamer at the start and end point of the process to record temperatures and pressure.
Continuous recording of residence time during every production	Residence time is one of the key parameters for microbiological inactivation. It should be determined for every product type and continuously monitored. For continuous processing, it can be defined through running trials using a sequence of product types differing in colour or shape. This way the end of the batch is clearly visible and the time can be measured manually. The parameter which is monitored during production is the rotation speed of the mixer, since a fixed residence time corresponds to this speed.
Generation of saturated, dry steam	Steam is generated in the boiler at a specific pressure. It is important to maintain a decrease in pressure along the entire steam line, down to the point of injection into the pre-heating and steaming. This creates expansion of steam with release of thermal energy to the external environment that avoids any formation of condensate. In this way, the steam along the entire line is in a saturated, dry state.
Management of start-up and shut-down	During start-up the entire steaming line must be heated to reach the target operational temperature. This will allow to reach the condition of saturated steam and avoid condensation with consequent temperature reduction. The steaming of product must not start until this target operational temperature is reached. During shut-down the product must not be treated because the temperature is decreasing below the target operational temperature.
Management of process deviations	In case of a process deviating from the set parameters, a clear procedure must be in place to initiate and perform the rework or disposal of the product.

## Maintenance of equipment



### Why are appropriate calibration and maintenance important?

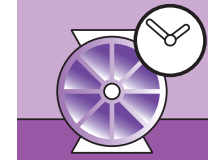
#### Calibration programs for measuring devices



All recording devices (e.g. for temperature and pressure measurements) should be calibrated at regular frequency. This should be done at least every six

months. For temperature probes an accuracy of  $\pm 0.5^\circ\text{C}$  is recommended\*.

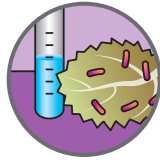
#### Replacement of pressure valves



When the steaming process uses temperatures above  $100^\circ\text{C}$ , a pressure tight valve is needed on the inlet and outlet of the steaming chamber to maintain overpres-

sure. Rotary valves are normally used for this application. Depending on the type of product processed, the deterioration of the valve due to abrasion from product can differ significantly. The lifespan of the valve should be determined and a valve replacement plan at regular, fixed frequency should be in place to keep good operational conditions during steaming.

\*"Guidelines for the Safe Production of Heat Preserved Foods", Department of Health, UK; Industry Handbook for Safe Processing of Nuts, GMA (2010)



**⚠ Why is validation so important?**

A deep understanding of the process parameters and the inactivation achieved during steaming of dry produce are key to understand the efficacy of the process.

**Microbiological validation study**

- A microbiological validation study is needed if the processing conditions applied are less stringent (shorter time, lower temperature, or both) than the ones reported as guidance (see page 11), or if another dried produce type is used, as extrapolation from one produce type to another is not possible. The outcome of the validation should be used as baseline to establish critical limits for processing.
- When a microbiological validation is needed a surrogate microorganism should be identified. For steaming, internal research and external guidance\* have shown that *Enterococcus faecium* (NRRL B-2354) has a similar heat resistance to the target pathogen (*Salmonella* spp) and can be considered a suitable surrogate for this process. Other microorganisms can be used as surrogate if there is scientific evidence that the dry heat resistance specific to the technology considered is similar

to the one of the target pathogen. When doing a microbiological validation, it is important to consider correct protocols for inoculum preparation and product inoculation to make sure the product physical characteristics remain unchanged.

- ⚠ The results of a validation study are valid exclusively for the process parameters applied to a specific product. Only if this connection is established is it possible to safely apply the process parameters on a daily basis.

**Microbiological reduction targets**

A 5 log<sub>10</sub> reduction of pathogenic bacteria like *Salmonella* is considered a safe reduction target for steaming of dry spices.\* Microbiological contamination of raw materials can vary widely for type of product and supply chain. When the frequency and level of occurrence of pathogenic microorganisms are known for a specific raw material, a tailored log<sub>10</sub> reduction that assures food safety can be calculated.

- ⚠ Processing conditions are considered safe when scientific evidence of the target bacterial reduction is available.

**Examples of safe processing reference conditions**

**Dried produce**



Steaming of basil ( $a_w=0.45$ ) at 85°C (product temperature), delivers 4 log<sub>10</sub> reduction of *Salmonella* after 5 minutes.



Steaming of whole peppercorn ( $a_w=0.57$ ) at 75°C (product temperature), delivers >5 log<sub>10</sub> reduction of *Salmonella* after 5 minutes.

**Steaming of fresh produce (blanching)**



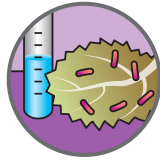
The steaming of fresh produce, also known as blanching, is a common practice in the primary processing industry. The main objective of this process is to inactivate enzymes that cause product degradation with quality loss (e.g. color change). Another objective of blanching is to soften the vegetable tissues in order to prepare them for further processing. Blanching is not generally considered a control point for pathogenic microorganisms. However, microbiological inactivation can take place depending on the process conditions applied. The choice of temperatures and processing times depends on the type of product to be processed but in general steam temperatures between 85 and 100°C are applied. In the case of blanching used as a control step for microbiological hazards, a microbiological validation study should be performed.

\*"Clean, safe spices." Guidance from the American Spice Trade Association (2017).

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## Verification

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### Why is verification so important?

- Verification should be done at an appropriate frequency on the finished product.
- *Enterobacteriaceae* as representatives of pathogenic bacteria such as *Salmonella* and Shiga Toxin Producing *Escherichia coli* (STEC) and target pathogens should be used for finished product testing.
- Analytical data should be collected over a defined period of time. This allows to do trend analysis and better control the process.

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## Good Manufacturing Practices (GMPs)

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### Why is it important to have GMPs in place?

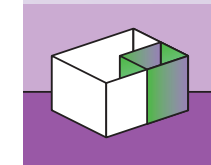
GMPs (as defined by CODEX - General Principles of Food Hygiene) are a collection of generally recognized rules, procedures and practices that together provide guidelines stating what is and what is not acceptable in the food industry. GMPs must be preventive in their approach. They ensure that food quality and food safety objectives are consistently met.

GMPs for zones and equipments (e.g. air-driers) positioned after steaming should be carefully considered to avoid re-contamination of the product.

For more information on GMPs, refer to “Good Manufacturing Practice (GMP) Guide for Spices” (2015), American Spice Trade Association.\*

\* <https://www.astaspice.org/food-safety/good-manufacturing-practice-gmp-guidelines-for-spices>

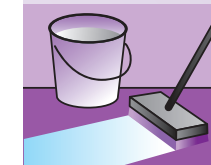
### Zoning



Zoning is the separation of areas with different hygiene levels. It can be applied to prevent spreading of microorganisms from a specific highly contaminated area to other

more critical processing zones. As an example, raw material reception should be separated from the packing area of the steamed dried product.

### Cleaning

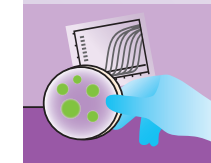


Cleaning must be considered as a process step, preparing the line for production. The equipment and the process environment must be clean and hygienically designed so they are not a source of contamination to products.

Cleaning is a mandatory action to keep the hygiene of the equipment and process facilities under control. Cleaning of zones having different hygiene levels must be done separately using different tools to avoid cross-contamination:

For areas where the steamed dried product is present it is important to reduce the use of water to a minimum (e.g. avoid wet cleaning and condensation). Effectiveness of cleaning should be verified at regular frequency (e.g. visual inspection, ATP analysis).

### Environmental monitoring



Environmental monitoring is the testing at pre-determined frequency of appropriate sampling sites (environment and product contact surfaces) identified

based on risk. Appropriate combinations of relevant pathogens and/or hygiene indicators should be analysed. The results provide the necessary information to keep the microbiological population in the processing area under control and to detect any cross contamination.

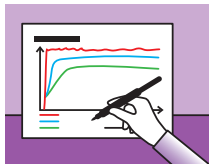


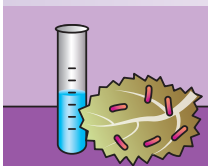

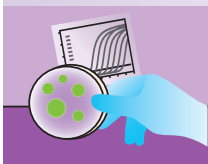

## Record keeping

### Why is it important to store records?

⚠ Records show evidence that a specific mitigation/control/preventive action has been taken at a specific time. Therefore, it is important to collect them in a timely manner (e.g. every 10 seconds for continuous recording or once for every batch

for manual recording) and keep them over time. A person should be responsible to do so.

The following are examples of records that should be collected and kept because of their importance to ensure the safety of the steamed products:

	Temperature and pressure profiles of new machines during commissioning and new products		Visual inspection sheet showing effectiveness of cleaning and maintenance records
	Residence time on every production batch		Validation and verification data
	Verification parameters measured after line reassembly		Environmental monitoring data
	Corrective actions report in case of process deviations and critical limits are not met (e.g. decision about product, cleaning to be done etc.)		





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