# Excerpt

**FROM THE REPORT ON THE AiF PROJECT**

# INVESTIGATIONS ON HOW TO OPTIMIZE THE DISINFECTION OF PACKAGING MATERIAL SURFACES BY ULTRAVIOLET IRRADIATION

## CHAPTER C
## RESISTANCE LIBRARY / CORRELATION

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# I. Devices and Methodology

## 1. UV System

For all experiments that were made within this project, we used high-intensity low-pressure lamps (UV SYSTEC, Jena).

The advantage of these high-intensity mercury low-pressure lamps is the controlled cooling of the apparatus. This cooling protects the UV lamp against overheating during a longer period of operation which could lead to a change in the wave length of the emitted UV radiation. Compared with “normal” low pressure lamps, high-intensity lamps can reach a higher UV output at a constant wave length (UV SYSTEC, 1997).

The systems consists of the following components:

UV Lamp Housing LH 2-50/UV-S for Surface Disinfection

For disinfection of the different packaging materials, a water-proof stainless steel housing type LH 2-50/UV-S with quartz window (outlet for the UV light) made by UV SYSTEC is used. This lamp housing is made for the use of an ozone-free low-pressure mercury lamp type XI 2-50. Through the use of specially doped quartz, the discharge tube is opaque to 185 nm radiation. Thus, there is no ozone generation. The integration of a UV sensor in the lamp housing and its connection with the electronic power supply unit guarantee for a constant UV-C radiation power (or: constant UV-C irradiation intensity) throughout the whole useful lifetime of the UV lamp. To discharge the dissipation heat, the UV lamp housing is water cooled.

Dimensions of the quartz window: 500 x 95 mm
Distance between quartz window and disinfected surface: 20 mm

Electronic Power Supply Type ebuv 750 dc master

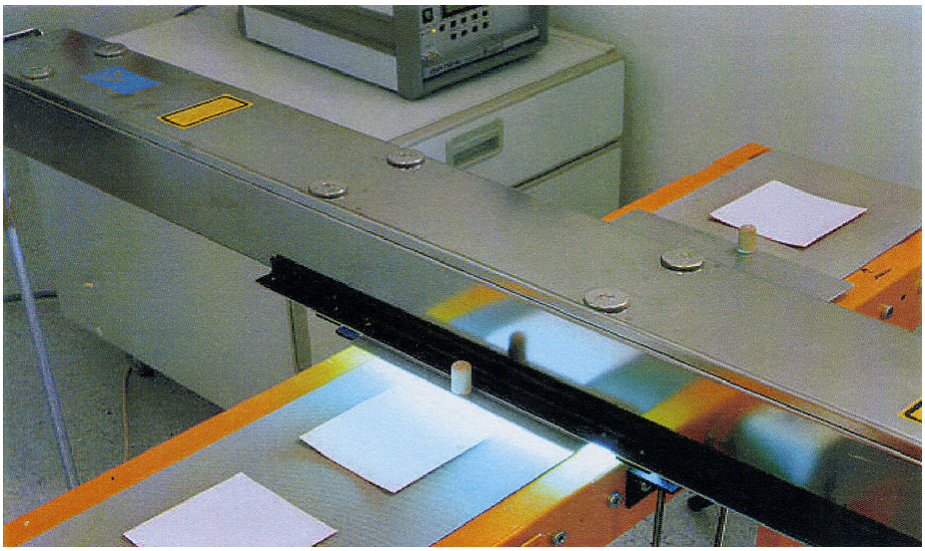
An electronic power supply type ebuv 750 dc master / slave is necessary to operate lamp housing and lamp. This unit supplies the electrical power and controls and monitors all operating parameters of the UV lamp. The UV rating can be set on the power supply in a range from 50% to 100%. Moreover, the operating hours and the number of ignitions of the UV lamp are recorded (UV SYSTEC, 1997).

UV-C Lamp Type XI 2-50

The UV lamp type XI 2-50 is a high-intensity low-pressure mercury lamp which distinguishes itself by a high radiation power in the wave length range from 200 to 280 nm.

For the resonance radiation at a wave length of 254 nm is approx. 25 %. At 254 nm, the radiation power is 162 W for a discharge current of 5 A, a mercury temperature of 60 °C and a shadowing effect of approx. 5%.

For a UV rating of 100% and a wave length of 254 nm, the average irradiation intensity, measured in a 20 mm distance between belt and quartz window, is 70 mW/cm² ± 10%.



Pic. 21: UV system

2. Methodology of Irradiation

The contaminated packaging pieces were irradiated by means of a transport belt moving below the UV lamp. The irradiation time was regulated by modifying the velocity of the belt. The irradiation intensities were set with suitable filters (L.O.T. Oriel GmbH ND-4-1 D-M, ND-2-1N-M). The transmissivities of the filters were 10%, 1%, 0.1% and 0.01 %.

II. Comparison: Aspergillus Niger (DSM 1957) / Bacillus Subtilis SA 22 (DSM 4181)

Because of their black color, the conidio spores of Aspergillus niger are considered to be the most UV resistant germs. In the following, this germ was compared with Bacillus subtilis which is used as testing germ particularly in the H2O2 disinfection of packaging material. Picture 22 shows the deactivation cinetics of these two germs at an applied irradiation intensity of 100 % corresponding to 70 mW/cm² (acc. to the lamp manufacturer). A. niger is much more resistant against UV irradiation than B. subtilis. For A. niger, the exposure time must be approx. 3 times higher to inactivate this germ by 3 decimal powers, for instance.

Due to their resistancies, both germs are well suited as reference germs. Both germs are no pathogenes and can thus be tested also on commercial plants. But A.niger can also grow on sour food such as yoghurt, fresh cheese and others and is there considered as spoiling germ. Therefore, its application in filling plants can be risky. For this reason and for its much easier handling, B.subtilis SA22 spores should be preferred as testing or reference germ.

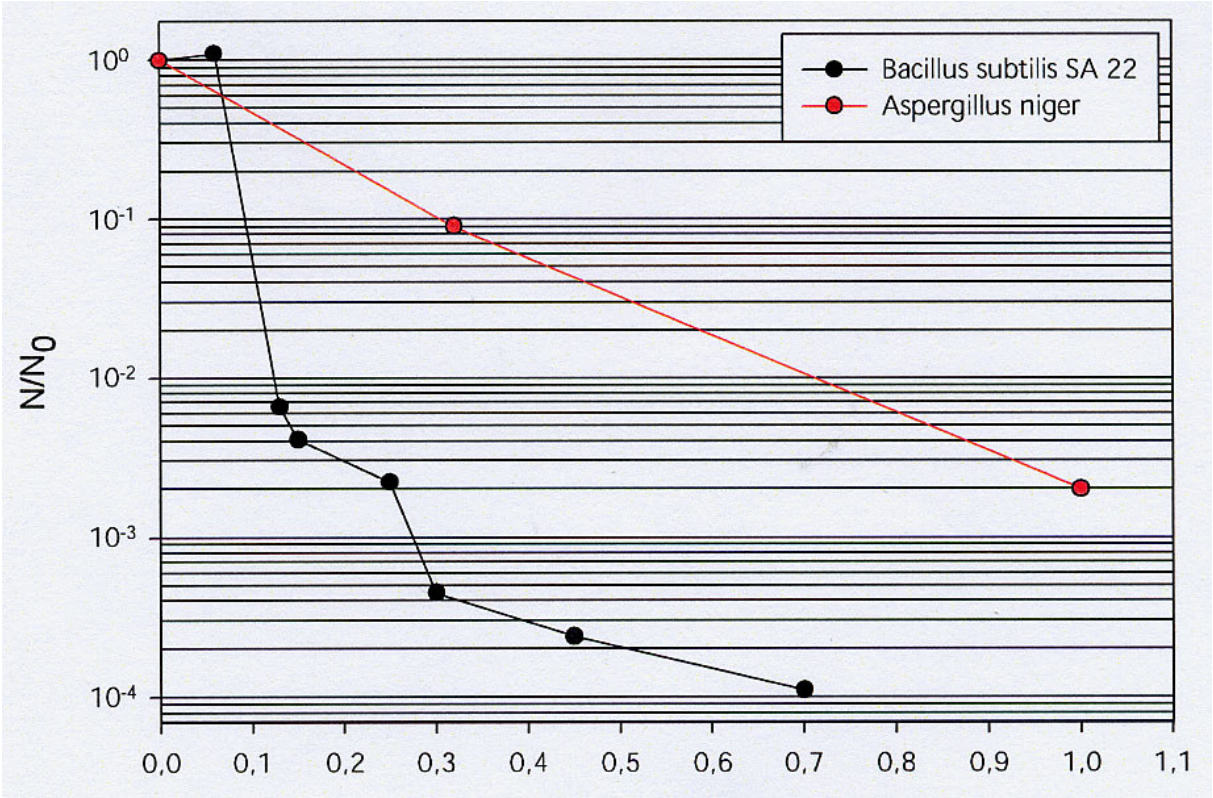



Fig. 22: Comparison of the deactivation cinetics of Aspergillus niger condidio spores and Bacillus subtilis SA22 spores (irradiation intensity: 100% corresp. to 70 mW/cm² - acc. to manufacturer)

The following figures 23 to 28 have resulted from tests with an irradiation intensity of 1 %. The germs were too sensitive towards UV – so the application of a higher irradiation intensity was unreasonable and unrealisable from a technical point of view. It was also technically not possible to irradiate A.niger with a 1% UV intensity. Therefore, we have to compare the resistancies of the following germs with B. subtilis SA22. A comparison with A.niger can thus be made indirectly.

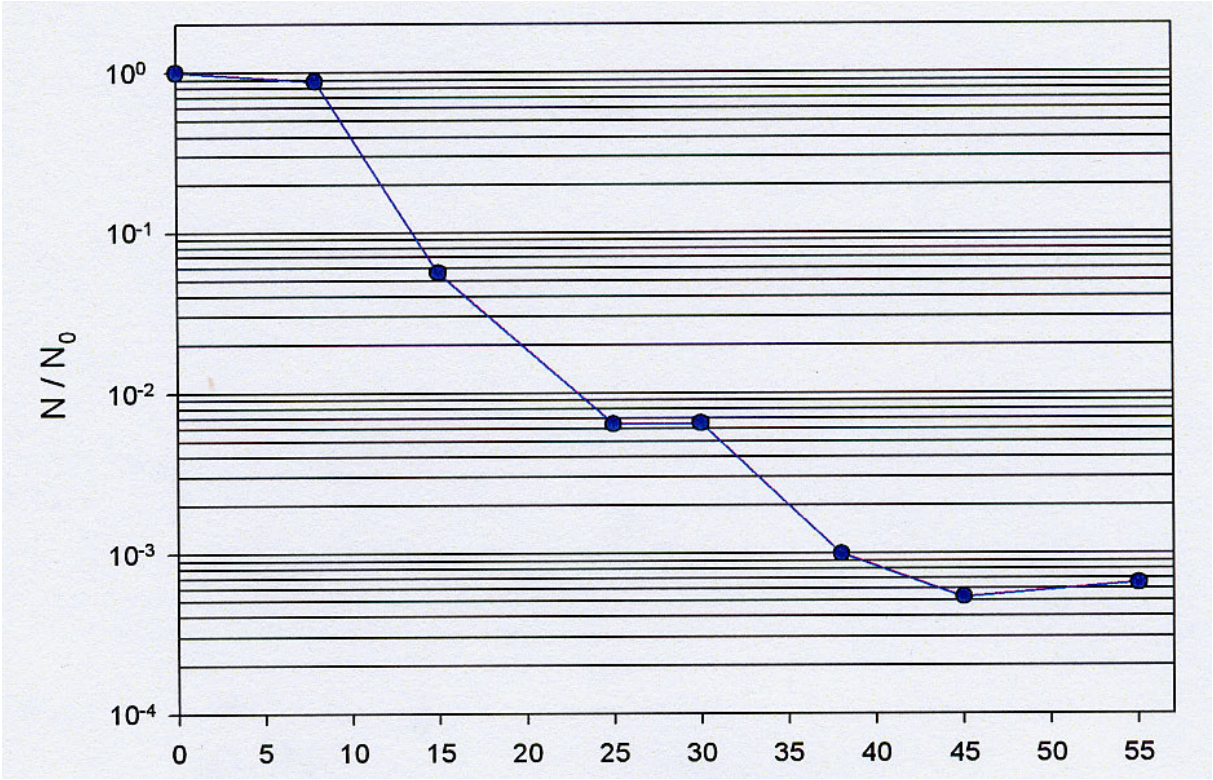



Fig. 23: Deactivation cinetics of Bacillus subtilis SA22 spores (irradiation intensity: 1% corresp. to 0.7 mW/cm² - acc. to manufacturer)

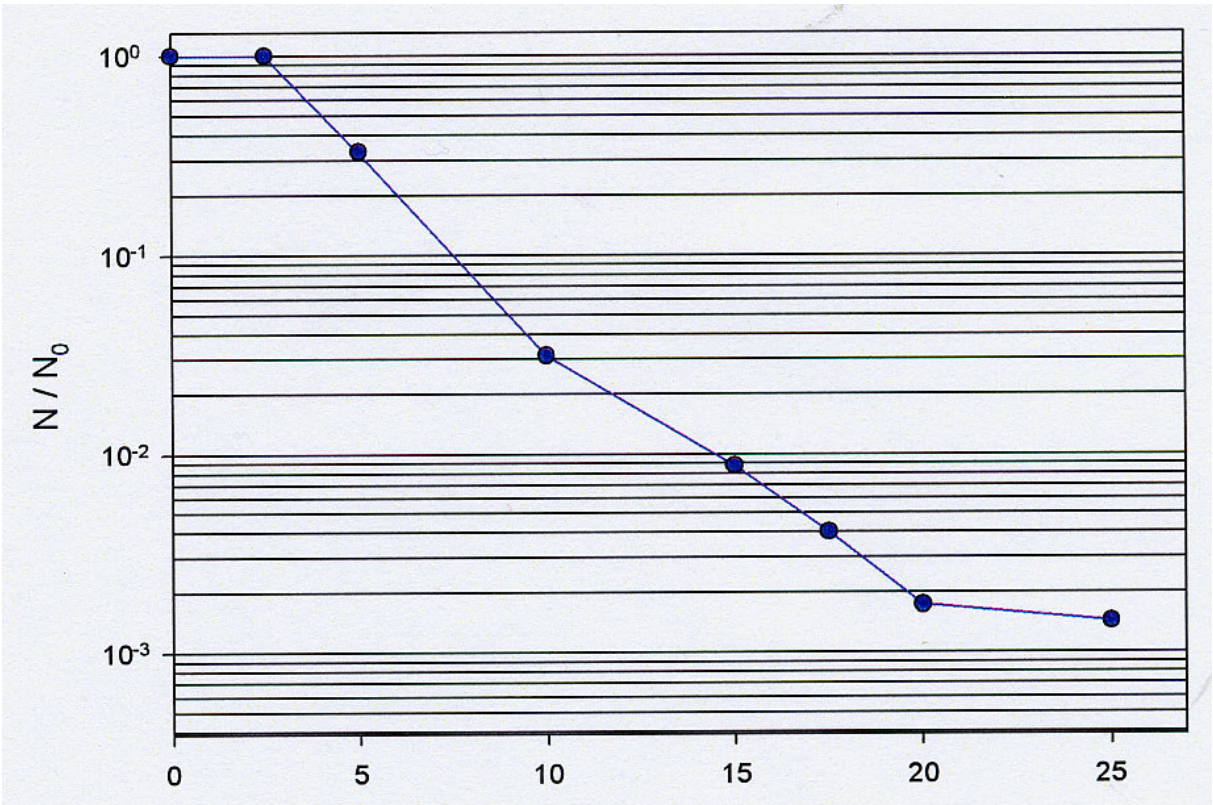



Fig. 24: Deactivation cinetics of Bacillus subtilis globigii (DSM 675) spores (irradiation intensity: 1% corresp. to 0.7 mW/cm² - acc. to manufacturer)

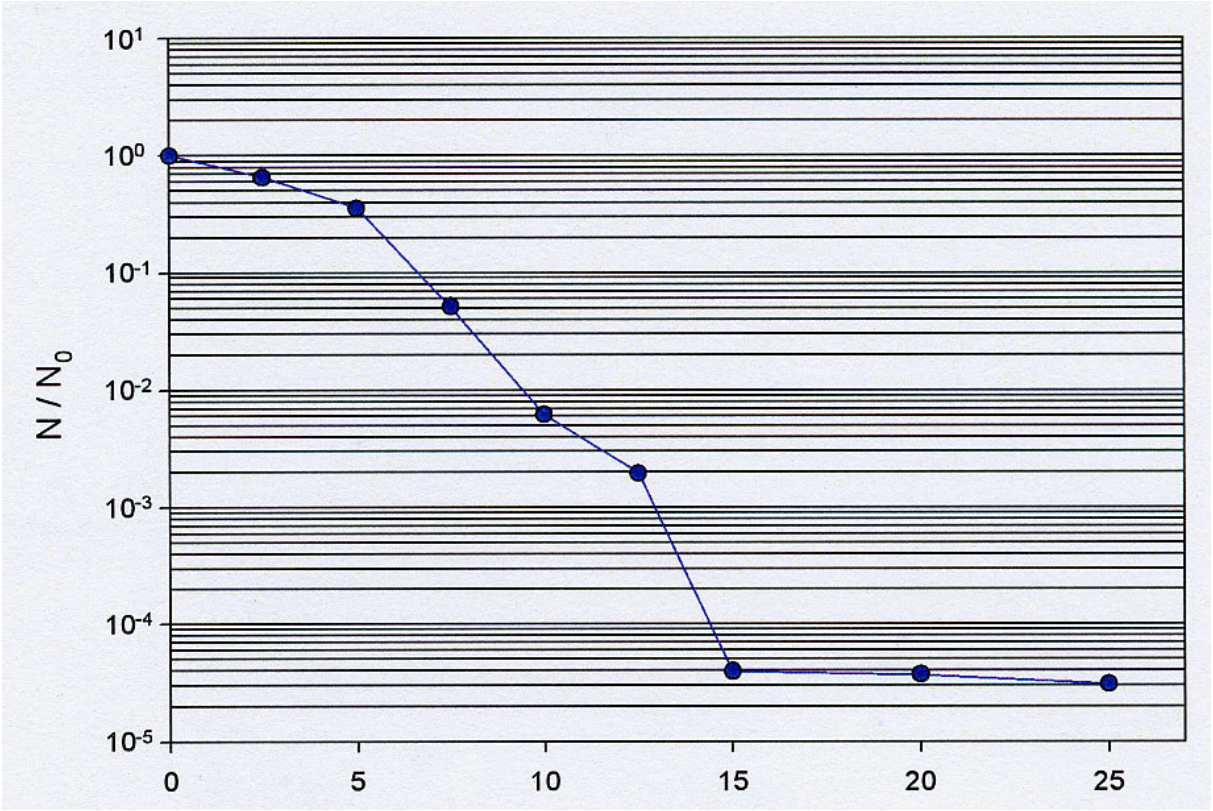



Fig. 25: Deactivation cinetics of Bacillus cereus (DSM 31) spores (irradiation intensity: 1% corresp. to 0.7 mW/cm² - acc. to manufacturer)

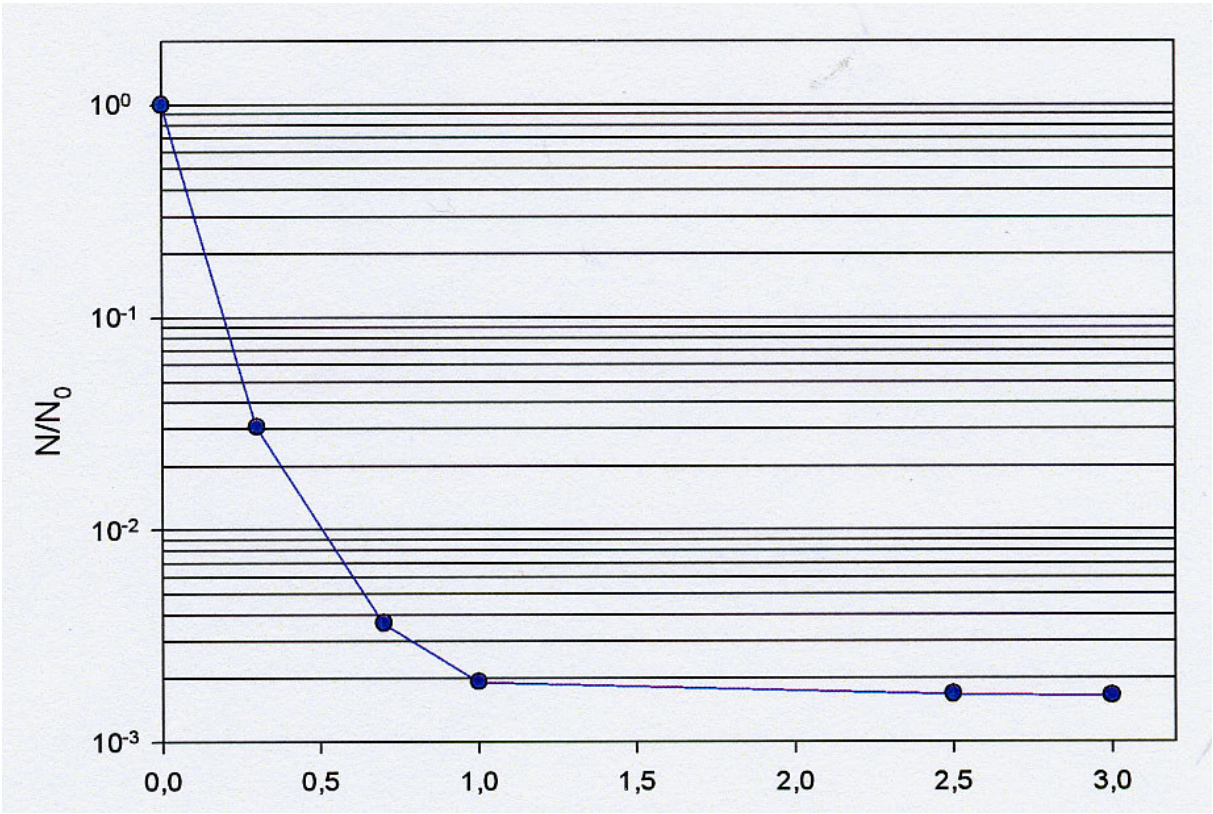



Fig. 26: Deactivation cinetics of Escherichia coli (DSM 1103) (irradiation intensity: 1% corresp. to 0.7 mW/cm² - acc. to manufacturer)

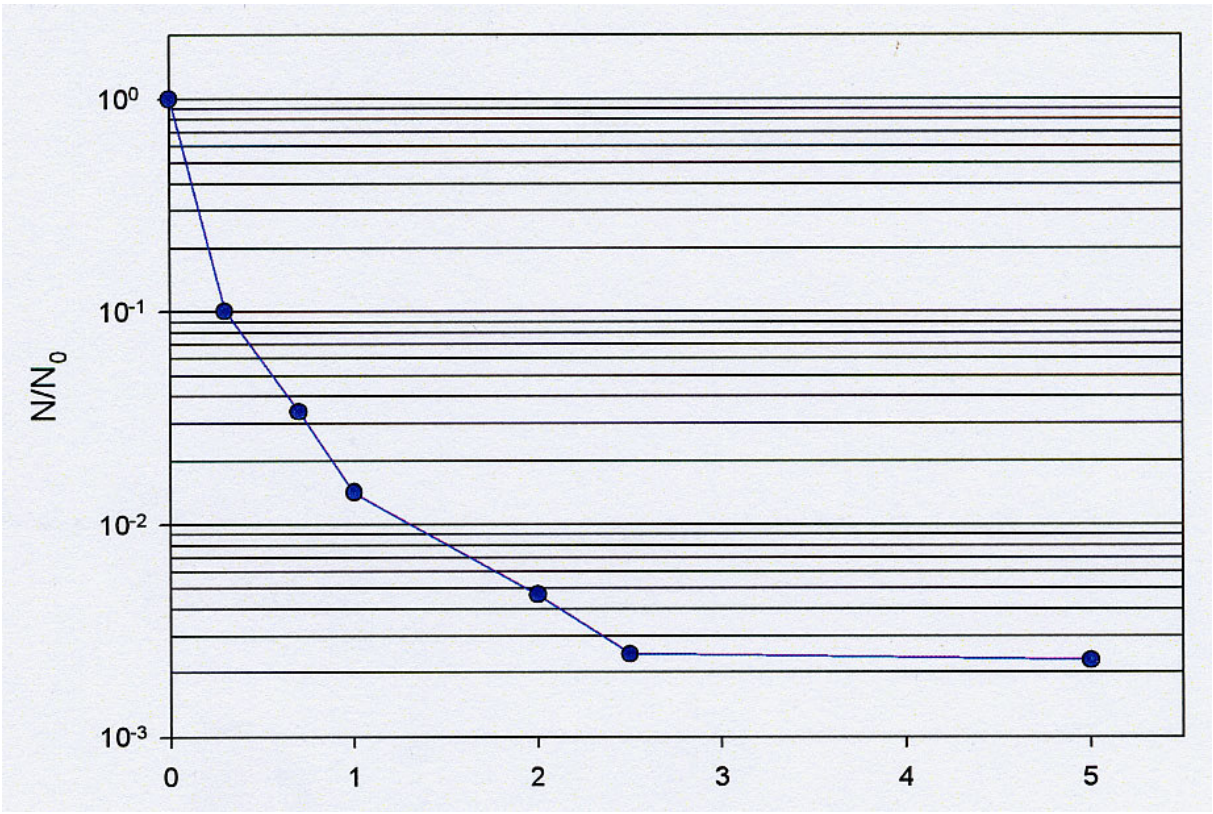



Fig. 27: Deactivation cinetics of Salmonella pona (irradiation intensity: 1% corresp. to 0.7 mW/cm² - acc. to manufacturer)

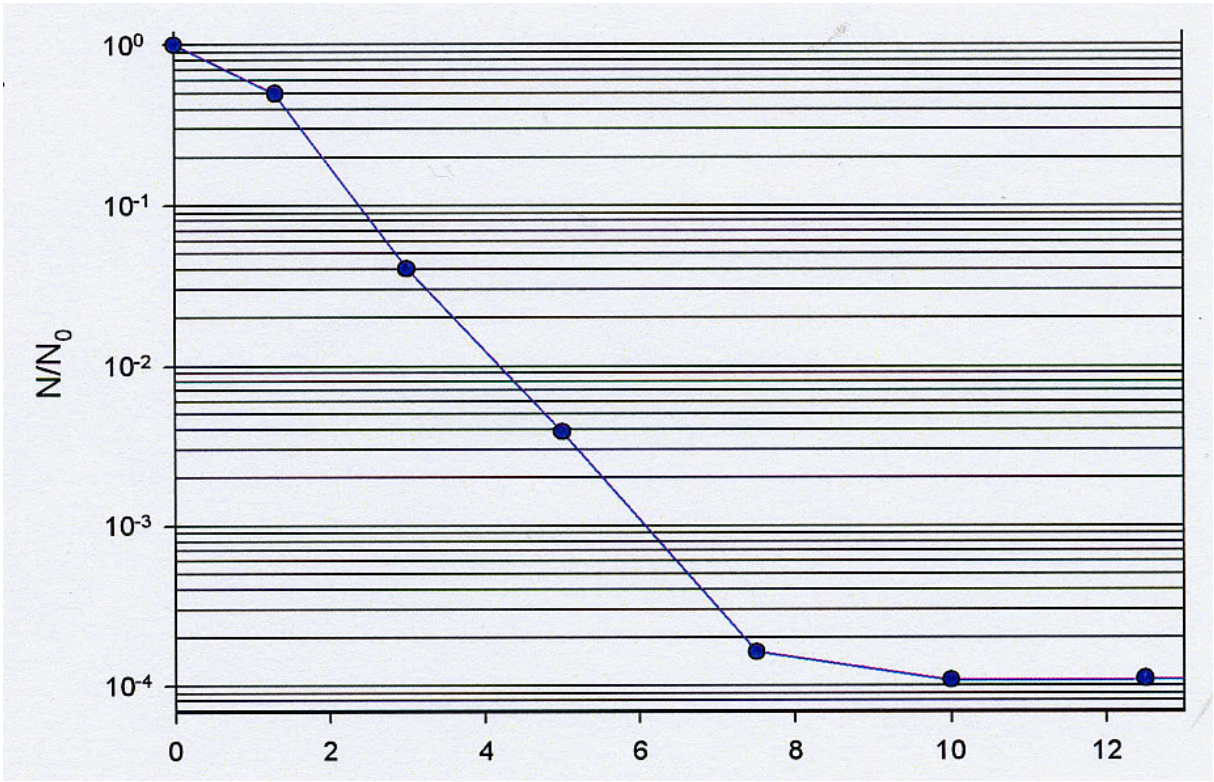



Fig. 28: Deactivation cinetics of Staphylococcus aureus (DSM 346) (irradiation intensity: 1% corresp. to 0.7 mW/cm² - acc. to manufacturer)

Table 4 shows the D and DRD-values of the tested germs compared to each other. Especially the correlation between the reference germ Bacillus subtilis SA22 which was taken here, illustrates the relative resistance of the germs against each other. It has come out that – in addition to the already mentioned very resistant A. niger and B. subtilis SA22 germs – some of the other Bacillus spores are still relatively resistant, whereas the vegetative germs are much more sensitive.

Unlike with thermal inactivation, the calculation of the z-value is not common for UV irradiation. This also seems not to be reasonable as the usual application of the D-values over the irradiation intensity for definition of the z-values does not result in a straight line and therefore not to constant values, what can particularly be seen in the following chapter (D.).

| Germ | D-value at 100% [s] | DRD-value at 100% [mJ/cm²] | D-value at 1% [s ] | DRD-value at 1% [mJ/cm²] | Correlation (relation) DRD – resp. germ / DRD B.subt.SA22 at 1% (0.7mW/cm²) |
|---|---|---|---|---|---|
| Aspergillus niger conidio spores | 0.38 | 26.32 | | | |
| Bacillus subtilis SA22 (DSM675)spores | 0.18 | 12.32 | 11.84 | 8.29 | 1 |
| Bacillus subtilis (DSM675) spores | | | 6.79 | 4.75 | 0.57 |
| Bacillus cereus (DSM31) spores | | | 3.5 | 2.45 | 0.30 |
| Staphylococcus aureus (DSM346) | | | 1.92 | 1.34 | 0.16 |
| Salmonella poona | | | 1.1 | 0.77 | 0.09 |
| Escherichia coli (DSM1103) | | | 0.38 | 0.27 | 0.03 |

Table 4