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Cross-contamination in dishwashers

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Summary Dishwashers are used in central hospital kitchens and ward kitchens to provide clean crockery. Soil recipes based on international standards were tested in order to evaluate the performance of a general dishwasher. In normal use of dishwashers, adherent soils are left on the crockery before cleaning. Different adherent soils, both with and without bacterial contamination, were used to show the effectiveness of the dishwasher to remove this type of soil. It was shown that contamination will occur from the dishwater to crockery with adherent soil. These results demonstrate the importance of cleaning soiled surfaces of crockery mechanically in the dishwashing process. Otherwise cross-contamination, and thereby the spread of infections, may occur.

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Introduction

The incidence of food-borne diseases has not decreased during the last few years.¹ The spread of infections in kitchens, especially hospital kitchens, can lead to serious problems for patients and staff. Incorrect temperatures during handling of the food, and poor personal hygiene of the workers in the food establishment, are the most important factors in causing the spread of disease. The third most important factor is cross-contamination in the kitchen.² The purpose of this study was to demonstrate that the mechanical cleaning of crockery is of great importance.³ First the dishwasher was checked to ensure that it met the criteria of the international standard ANSI/NSF 3-2001⁴ and the

German standard DIN 10512.⁵ Thereafter, it was shown that with more adherent soiling, it was likely that not all of the soil was removed from crockery during the washing procedure and that bacteria could survive in this soil. Finally, it was demonstrated that there was a risk of cross-contamination of bacteria from the dishwater to the crockery if there were soil residues present.

Materials and methods

Test surfaces: metal test plates according to the DIN-standard^{5,6} and porcelain plates

The metal test plates were made from austenitic manganese steel, with a longitudinal grinding by abrasive 80. The metal test plates were washed with detergent and water, treated with acetone to

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remove fat and water residues and sterilized (steam, 121 °C, 20 min) before use. The size of the active area of the metal test plate was 9 cm² (Figure 1). The porcelain plates had an outer diameter of 250 mm and a soiled area with a diameter of 160 mm, resulting in an active inner area of 200 cm². All the porcelain plates were sterilized before use. The following test soils were made up.

The machine used was an Electrolux WT 60 E, one tank dishwasher¹⁰ which had three program modes: lightly soiled, normally soiled and heavily soiled crockery. In this investigation the program for normally soiled crockery was used with a cycle time of 65 s. The dishwasher temperature was 64 °C and the rinse water was 87 °C. The detergent used was Gigant (60% NaOH and 40% NTA) and the drying agent was Solid Clear Dry HD (45% non-ionic surfactants and 55% urea). The concentration of detergent was 2 mL/L water resulting in a pH of 11.6 in the wash water. After normal cleaning, it was started up according to the manual.¹⁰ To ensure identical conditions in the dishwasher, three programs were run before each experiment. Racks were cleaned in the normal dishwashing programs before use.

Test of standards

The inner circles of five porcelain plates were soiled with test soil A, milk (1% fat). The plates were dried for 45 min at room temperature, then at 37 °C for 17 h according to the ANSI/NSF standard⁴ (Figure 2(a)). The remaining positions in the rack were filled with clean porcelain plates. The soiled plates were placed in positions L2, L6, L9, R4 and R8, (Figure 3). After the dishwashing process, all the porcelain plates were visually inspected. Cleanliness was defined visually.

Eight metal test plates soiled with test soil B which was made up as follows: Maizena[®] maize starch (180 g) was mixed in 1.2 L tap water. Castor sugar[®] (1 kg) was added and the solution was heated and agitated, until boiling, to obtain homogeneity. The solution was removed from the heat, and 10-20 drops of food colour (E104, E131) were added. The soil was smeared over the metal test plates, and

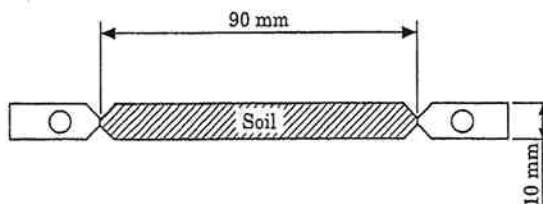


Figure 1 Test plate according to DIN 10512.

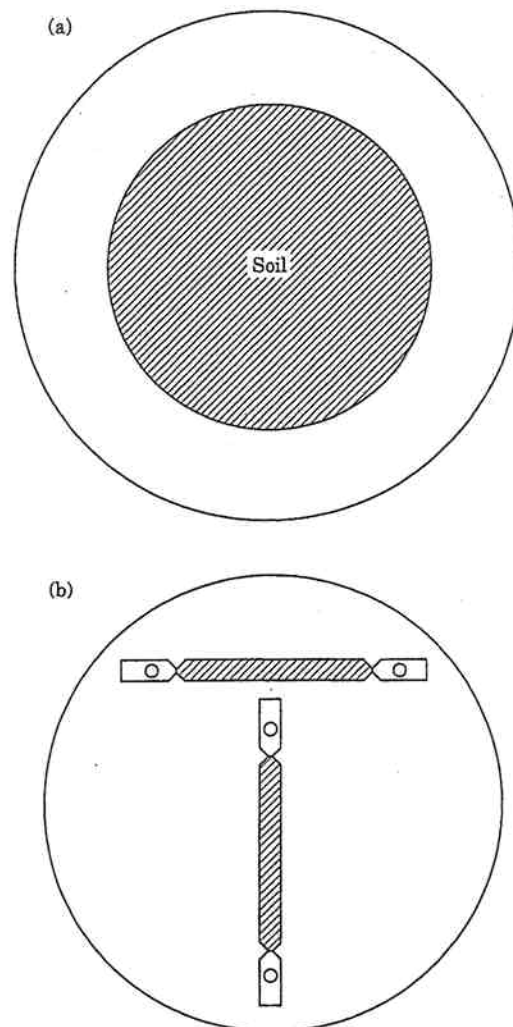


Figure 2 (a) Porcelain plate with soil. Shaded areas soiled. (b) Metal test plates mounted on a stainless steel plate.

dried in a convection oven at 95 °C for 60 min. Soiled metal test plates and clean porcelain plates were put in a rack according to Figure 2(b), with two metal test plates on each side of two circular steel plates at positions L7 and R2. After the dishwashing process the result was evaluated by visual inspection.

Ten metal test plates were soiled with test soil C which was made up as follows: albumen, 0.060 g [fraction V (0.6% MERCK[®]; CAS 9048-46-8)], was dissolved in 3 mL sterile H₂O in a sterile glass tube. Mucin, 0.10 g [1.0% mucin (type II) SIGMA[®] (CAS 84082-64-4)], was dissolved in 3 mL H₂O in a glass tube and sterilized (steam, 121 °C, 20 min). Maize starch (3% CABIOCHEM), 0.30 g, was dissolved in 3 mL H₂O in a glass tube and sterilized. The 3 mL solutions of albumen, mucin and maize starch were

9	9
8	8
7	7
6	6
5	5
4	4
3	3
2	2
1	1

Left Right

Figure 3 Plate positions in the rack.

mixed in a sterile glass tube and 1 mL of 0.9% NaCl solution containing 1.0×10^{10} cfu/mL *Enterococcus faecium* (CIP 106742; DSM 2146; ATCC 6057)⁷⁻⁹ was added, giving a final volume of 10 mL. The soil (0.1 mL), was transferred to each of the test plates using a pipette. The soil was spread evenly over the surface with a glass bar. The metal test plates were then dried for 5 h at 20-24 °C and a relative humidity of 50-70%.

Eight soiled plates were placed with two soiled metal test plates on each side of two circular steel plates, at positions L3 and R6. Sterilized porcelain plates were placed in the remaining positions of the rack. After the dishwashing process, the metal test plates were visually inspected and evaluated according to the DIN standard,^{5,6} which requires a \log_{10} reduction factor of 5 in bacterial count. The two soiled metal test plates that were not put in the dishwasher, were used as the reference and evaluated according to the DIN standard.^{5,6}

Thermal resistance test^{5,6}

The thermal resistance of *E. faecium* was tested by keeping 20 metal test plates, soiled with test soil C, at 70 °C for 10 min. They were kept in separate sterile glass tubes containing a broth (tryptic soy broth MERCK® 1.05459). The soil formulation was considered acceptable if growth of micro-organisms was detected in 18 of the 20 of the test tubes.

After the experiments were performed, the metal test plates were evaluated according to the DIN standard.^{5,6} They were put individually into

sterile glass tubes, with 10 mL of 0.9% NaCl, and agitated for 30 s, using a test tube shaker. From the solutions, ten-fold dilution series were made and the samples were spread on kanamycin aesculin azide agar (Oxoid® CM0591) including kanamycin sulphate supplement (Oxoid® SR92), with a glass rod. All the samples were prepared in duplicate and 0.05 mL were spread on the Petri dishes. The dishes were incubated upside down at 36 ± 1 °C for 48 h.

Test of bacterial activity in test soils I and II

To check the survival of *E. faecium*, after the drying process in a hot cabinet (50 °C for 24 ± 1 h) in the more adherent soils in test soils I and II, metal test plates were prepared.

Test soil I consisted of 10 g egg powder that was mixed with 50 mL tap water until completely dissolved. Then 20 g castor sugar was dissolved in the remaining water and the solution heated until boiling. The solution was removed from the heat, 50 g potato powder (Felix®) and dissolved egg powder were added and the solution was then stirred until it was completely homogenous.

Test soil II consisted of 10 g egg powder mixed with 50 mL water until completely dissolved. Twenty grams of castor sugar was dissolved in 150 mL water and the solution heated until boiling. Thirty grams of frozen chopped spinach (Felix®) was added and defrosted in the boiling water. The solution was removed from the heat and 50 g potato powder (Felix®) and dissolved egg powder were added. The solution was stirred until it was completely homogenous.

In the test soils I and II with the bacterial load, 1 mL of a 0.9% NaCl solution with 1.0×10^{10} cfu/mL *E. faecium* was added to 20 g soil. One gram of the soil with bacterial load was applied to the sterilized metal test plates. The soiled test surfaces were dried in a hot cabinet at 50 ± 1 °C for 24 ± 1 h.

Dishwashing test of soils I and II

Ten metal test plates were prepared with soil according to test soil I and 10 prepared according to test soil II. Both batches received a bacterial load. The metal test plates were mounted, four by four, on circular steel plates and placed in the rack of the dishwasher.¹⁰ The rack was then filled with sterilized porcelain plates and dishwashing performed. The remaining four metal test plates for test soils I and II were used for the control of bacterial activity within the soils. The bacterial activity was evaluated by checking the colony-forming units per test plate, according to the DIN standard.^{5,6}