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RESEARCH ARTICLE

Hygienic aspects of using wooden and plastic cutting boards, assessed in laboratory and small gastronomy units

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Abstract There is a long-term controversy on the safety of using hardwood cutting boards in food preparation. This study was designed to compare three types of cutting boards (maple, beech wood, polyethylene) in the laboratory and in a small gastronomic unit. Samples for microbiological analysis were collected by a swabbing method from the boards' surfaces that had been contaminated with a defined meat–egg-mixture and subsequently cleaned according to manufacturers' instructions. Our study did not show significant differences between the microbiological status of the three types of cutting boards tested, all of them being overall acceptable. Use of the maple board in a small gastronomic unit for 2 months did not result in problems in cleanability.

Keywords Cutting boards · Wood · Plastic · Hygiene · Cross-contamination

1 Introduction

Nowadays, cutting boards for food processing are available in a variety of materials such as: different types of woods, bamboo, polymers, glass, stainless steel etc. However, until the early 1970s, wood was the predominating material (Ak et al. 1994).

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Cross-contamination of foods with foodborne pathogenic bacteria is a major cause for foodborne diseases. Van Asselt et al. (2008) emphasized that cross-contamination of food at home was an important factor, and suggested it could be included in microbiological risk assessments (MRAs) performed for the whole food supply chain.

The present regulations and standards on cutting boards are mainly based on the assumption that wooden cutting boards are difficult to clean. Annex II Chapter V No. 1 (b) of Regulation (EC) No. 852/2004 (European Community 2004) indicates that "all articles, fittings and equipment with which food comes into contact are to (a) be effectively cleaned and, where necessary, disinfected. Cleaning and disinfection are to take place at a frequency sufficient to avoid any risk of contamination; (b) be so constructed, be of such materials and be kept in such good order, repair and condition as to minimize any risk of contamination". According to Annex 1.1 of the German "General Procedural Regulation on Food Hygiene" (AVV Lebensmittelhygiene 2009), the risk of contamination is normally not minimized if wooden equipment is used for purposes other than chopping blocks, smoking and ripening rooms and pallets to be used for transportation of packaged food.

Sector-specific guidelines, including various Guides to Good Hygienic Practice notified according to Directive (EC) No. 93/43 (European Community 1993) and Regulation (EC) No. 852/2004 (European Community 2004), describe the properties of food contact materials. Generally, they should be smooth, free of grooves and cracks, easy to be cleaned and, where appropriate, to be disinfected. Some Guides also provide recommendations on the material of the items.

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For the present study, guides prepared for gastronomy and catering units are relevant. The Guide to Good Hygienic Practice prepared by the DEHOGA (2006) for gastronomy does not specify the material for food contact items. In the 2010 version of the Guide to Good Hygienic Practice in small movable and/or temporary premises, published by the Berufsgenossenschaft Nahrungsmittel und Gaststätten (2010), it is stated that "tools and contact surfaces made from wood, as well as cutting boards from plastic, must be clean and must have a smooth surface without grooves. They must be kept in good conditions. For many purposes, wood surfaces are not appropriate, due to their porous surface. In exceptional cases, for technological reasons, wooden tools and surfaces are used, e.g. for rolling out doughs for baked goods, and for chopping blocks in meat processing. This requires higher efforts for cleaning". According to the Guide to Good Hygienic Practice for catering units (Deutscher Caritasverband und Diakonie 2009), furnishing in large kitchens should not be made from wood while for tools including cutting boards, it is only stated that they should not consist of soft wood or soft plastics.

On the other hand, Ak et al. (1994) pointed out that there is poor evidence that the restrictions of use of wooden cutting boards in food processing industry and in gastronomy is justified by hygienic arguments. In their experiments, the recovery of bacteria from the surface of experimentally inoculated wooden blocks was much lower than from plastic boards, indicating that bacteria are absorbed and sucked into the wood. This study triggered various other studies on the fate of bacterial contaminants on cutting boards. Rödel et al. (1994) could recover inoculated bacteria from samples retrieved from the upper 0.25 mm layer of wooden cutting boards, especially after the bacteria had been inoculated together with bovine serum albumin. However, Boursillon and Riethmüller (2007) did not observe differences between beechwood and polyethylene boards with respect to remobilization of bacteria, and Cliver (2006) stressed that re-transfer of bacteria from the interior of the wood to food via knives has not been demonstrated yet. Wood constituents, especially those from pine, may also play a role in inactivating adsorbed bacteria (Milling et al. 2005). Gehrig et al. (2000) reported that bacteria may grow on cutting boards while wet, and that wooden boards with porous surface dry faster. Moreover, they found that surface scars on used wooden boards did not affect this process while scars in plastic boards delay drying considerably.

Taken together, there is still controversy on the hygiene of using wooden cutting boards but reviews on this problem (Carpentier 1997; Lauzon 1998; Cliver 2006; Stingl and Domig 2008) and various other recent studies (e.g. Prechter et al. 2002; Milling et al. 2005; Boursillon and Riethmüller 2007) concluded that there is no evidence for the superiority of plastic cutting boards.

In the USA, it is permitted to use hardwood cutting surfaces in commercial food preparation provided the surface material had been certified by the National Sanitation Foundation (NSF). This is why we included in our study a cutting board made from NSF-certified North American hard maple. We also tested this board in a real gastronomy environment where boards are used continuously and accumulate cuttings. In laboratory experiments (sporadic, gentle and careful usage with no surface damage), we also compared the maple board with one board from beech and one board from polyethylene under hygienic aspects. For this, we assessed the microbial contamination by enumerating total aerobic mesophilic microorganisms and *Enterobacteriaceae* on cutting boards after artificial contamination and common cleaning procedures.

2 Materials and methods

2.1 Cutting boards used

For the purpose of this study, we used three types of cutting boards, namely, made from hard North American maple certified in the USA by National Sanitation Foundation (NSF) (manufacturer: John Boos & Co.; Brand: Boos Blocks®), beech wood, as commonly used in homes (manufacturer: Roesle), and polyethylene hard plastic widespread in the food industry (manufacturer: Dick). All boards were new and hand-washed before the first use. To maintain the surface quality and a good cutting performance, the instructions provided by the producer of the maple board were followed: the board was oiled with special mineral oil (BoosBlocks® Mystery Oil) before the first use and after the third round of the laboratory experiments, and after 3 weeks of use in the bistro unit, respectively.

Different cleaning conditions were applied for plastic and wooden cutting boards. The plastic board was placed in an industrial dishwasher (Winterhalter UC-L) using standard detergent (Winterhalter F 8400) and conditions (washing temperature of 60 °C for 2 min, followed by rinsing at 85 °C), then wiped with

clean cloth and left to dry for 30 min. Wooden boards were hand washed under warm tap water with commercially available washing liquid (Palmolive®) and by using a soft cloth. After that they were wiped with clean cloth and air dried for 30 min.

2.2 Method of artificial contamination

As a contaminant used in the laboratory experiments, a food mixture, based to some extent on food items used for testing of cleaning performance of household used dishwashers, as specified in the standard DIN EN 50242/EN 60436 (2008), was prepared as follows: Minced meat was purchased in a local supermarket, transported to the laboratory kitchen and left at room temperature for 12 h (in order to stimulate microbial growth). Then, 75 g of minced beef and 75 g of minced pork were mixed with the contents (albumen and yolk) of a medium-size egg (50 g). The resulting mixture had a pH of 5.8. 20 g of the mixture were then removed for microbiological analysis, homogenized in 180 ml of 0.85 % sodium chloride solution containing 0.1 % tryptone. Appropriate dilutions were then spread on Plate Count Agar (PCA; Merck KGaA, Darmstadt) and Violet Red Bile Glucose Agar (VRBG; Merck KGaA, Darmstadt), for the enumeration of aerobic mesophilic microorganisms and *Enterobacteriaceae,* respectively, and incubated at 30 °C for 2 days. In the contaminant mixture, *Pseudomonas* spp. were also enumerated, using Cetrimid Fucidin Cephaloridin Agar (CFC; Oxoid No. CM 0559). For the subsequent contamination experiments, the remaining mixture was rapidly frozen and stored at −21 °C.

2.3 Design of the study

The experiments were designed in a way to simulate normal usage conditions of cutting boards at home and in small gastronomic units. In addition, boards were tested in a laboratory setting where they are no cuts with knives. The first part of the study was performed in a laboratory kitchen at Fulda University of Applied Sciences, and the second one took place in a bistro-type unit which provides meals for company workers and thus served as a model for conditions in small gastronomy units and in private households.

In the first part of the study, all three cutting boards (maple, beech and plastic) were examined in five repeated experiments. For each repetition, the frozen food mixture (prepared as described in Sect. 2.2) was thawed in cold water for about 30 min. 30 g of the mixture were then mixed with 8 ml of cold tap water, applied to the boards and left for 10 min. In the meantime, the un-inoculated part of the board was swabbed. After the food mixture had been removed from the boards, they were left for 2 h at room temperature. Subsequently, the contaminated area was swabbed. Then, boards were washed as specified above, wiped with clean cloth and left to dry for 30 min. The last two samples were then taken by swabbing the un-inoculated (control) areas and contaminated areas of the boards, respectively.

In the second part of the study, only the maple board was used. It was washed and oil treated similarly as the other wooden boards in the first part of the study before starting the experiments. It was left with a small gastronomy unit (company bistro) for 2 months. During this time the board was used once every working day for about 1.5 h for preparation of sandwiches (cutting fresh vegetables, bread and rolls, breakfast meat products and cheeses) and cleaned manually after use. Samples were taken three times (after the 2nd, 5th and 8th week of use). At each sampling day, the first swab was taken after the preparation of the last sandwiches and the second swab after cleaning. After 2 months of use in the bistro, the board was transported to the laboratory kitchen. There, it was artificially contaminated, washed and sampled in the same way as in the first part of our study, in order to find out differences between the maple board used in the laboratory kitchen (no cutting on the board and no damage to the surface) and the one used in the small gastronomic unit (frequently used and with visible grooves on the surface).

2.4 Sample coding, collection and analysis of samples

Samples were removed by swabbing from the surface of 20 cm^2 and placing the swabs in 5 ml 0.85 % saline solution. Subsequently, this dilution was inoculated on: Plate Count Agar (PCA, Merck KGaA, Darmstadt) and Crystal violet Neutral Red Bile Glucose Agar (VRBG, Merck KGaA, Darmstadt), incubated aerobically for 48 h at 30 °C, in order to obtain CFU/cm^2 of aerobic mesophilic microorganisms and *Enterobacteriaceae,* respectively. The results were calculated according to standard DIN 10113-1 (1998). The detection limit was 2.5 CFU/cm^2 (50 CFU/sample).

3 Results and discussion

Samples from new cutting boards without grooves, obtained in the laboratory kitchen before cleaning, had mean counts of aerobic mesophilic microorganisms of 7.5, 23.5 and 41 CFU/cm^2 for maple, beech and plastic boards, respectively. No *Enterobacteriaceae* were detected. The meat-egg mixture used for contamination of the boards contained 1.7×10^7, 7.7×10^3 and 4.5×10^6/g of mesophilic aerobes, *Enterobacteriaceae*, and *Pseudomonas* spp., respectively. Samples obtained from the boards after artificial contamination had 327 CFU/cm^2 (maple board) and more than 500 CFU/cm^2 (beech and plastic board). *Enterobacteriaceae* were found on only 4 of 12 samples tested, with counts not exceeding 45 CFU/cm^2. The data are summarized in Table 1.

After cleaning, no *Enterobacteriaceae* were detected in any sample. Moreover, 23 of 30 samples had less than 2.5 CFU/cm^2 of aerobic mesophilic microorganisms, irrespective of previous contamination. Of the remaining 7 samples having counts between 2.5 and a maximum of 32.5 CFU/cm^2, 3 were obtained from the beech wood board, and 2 each from the maple and plastic board.

Results from experiments performed in a small gastronomic unit using the maple cutting board are compiled in Table 1, too. Samples were collected three times from the board before and after the cleaning procedure. The results obtained after 2 and 5 weeks of use did not differ significantly from those obtained after 8 weeks of use and were not included into Table 1. Cleaning of the board gave reduction of aerobic mesophilic microorganisms to 5 CFU/cm^2 or below. All samples collected had <2.5 CFU/cm^2 of *Enterobacteriaceae*.

The final part of the study was performed in the laboratory kitchen with use of all three types of cutting boards (maple, beech and plastic) as well as and the maple board used previously in the bistro in Experiment 2). This trial was conducted according to the procedure in Experiment 1. Important difference between maple board from Experiment 1 and the maple board used for 2 months in bistro was the presence of small grooves from knife cuts on the surface of the bistro board. Bacterial counts on the boards used in the laboratory kitchen were similar to those obtained in the first experiment and therefore included in Table 1. Only the aerobic mesophilic count on one plastic board after cleaning (32.5 CFU/cm^2) was classified as unacceptable. Counts on all wooden boards after applying the cleaning procedure can be qualified as acceptable. The maple board used in the bistro for 8 weeks contained more than 500 aerobic mesophilic bacteria before and no detectable bacteria (<2.5/cm^2) after cleaning.

Table 1 Counts of microorganisms on cutting boards before and after cleaning

Inoculated	Status cleaning	Type of the board	Samples with aerobic mesophilic count/cm^2				Samples with *Enterobacteriaceae*/cm^2		
			<2.5	2.5–24	25–249	>250	<2.5	2.5–24	25–250
No (control)	Before	Maple (used in laboratory)	4	1	1	0	6	0	0
		Maple (used in bistro)	1	0	0	0	1	0	0
		Beech	2	4	0	0	6	0	0
		Plastic	1	4	1	0	6	0	0
	After	Maple (used in laboratory)	5	0	1 (32.5)	0	6	0	0
		Maple (used in bistro)	1	0	0	0	1	0	0
		Beech	4	2 (12.5; 2.5)	0	0	6	0	0
		Plastic	5	0	1 (37.5)	0	6	0	0
Yes	Before	Maple (used in laboratory)	0	0	2	4	5	1	0
		Maple (used in bistro)	0	0	0	4	4	0	0
		Beech	0	0	0	6	2	0	4
		Plastic	0	0	0	6	1	2	3
	After	Maple (used in laboratory)	5	1 (7.5)	0	0	6	0	0
		Maple (used in bistro)	2	2 (5; 2.5)	0	0	4	0	0
		Beech	5	1 (2.5)	0	0	6	0	0
		Plastic	3	2 (2.5; 2.5)	1 (32.5)	0	6	0	0

Counts above 2.5 CFU/cm^2 on cleaned boards are given in brackets

Similar results were reported by Miller et al. (1996) who found no significant differences in bacterial loads on plastic and hardwood cutting boards after contamination with ground beef and subsequent cleaning.

Kleiner and Lampe (2014) also compared the Boos Blocks® maple cutting board with a polyethylene board, by cutting chicken or salad on them and manually cleaning them. In terms of hygiene, they found the oil-treated maple board equal or superior to the polyethylene board, even after various use and cleaning cycles over 4 weeks, with ever increasing numbers of scratches on the boards. The lowest counts after cleaning were obtained from a maple board not treated with oil. Apparently, the contaminant liquid was sucked into this board, and bacterial contaminants may also have been inactivated by wood constituents.

In the studies performed by Cools et al. (2005) and Moore et al. (2007), the inactivation of microorganisms (*Campylobacter jejuni* and *Salmonella* Typhimurium, respectively) on the surfaces studied (including beech wood, polypropylene, stainless steel and Formica) over time was measured. In both studies, there was a significant reduction of recovered microorganisms with time from all tested surfaces. Cools et al. (2005) did not observe significant differences between materials while Moore et al. (2007) found a much faster inactivation on wood.

The authors studying the recovery of microorganisms from common food contact surfaces, especially in home kitchens, uniformly highlight the need for proper cleaning and disinfection of used utensils (especially cutting boards) in order to minimize the cross-contamination effect. Repeated cleaning of wooden boards in the dishwasher under harsh conditions resulted in cracks sufficiently large to entrap bacteria, and in adsorption of organic matter and bacteria (Welker et al. 1997), and should be avoided.

There are no legal standards on acceptable microbial counts on food contact surfaces, and it makes little sense to introduce them (see e.g. ICMSF 2002). However, the repealed Decision 2001/417 by the European Commission (European Community 2001) stated that on surfaces which are cleaned, dry and smooth, and which have contact with meat or poultry in slaughter houses or cutting rooms, total viable counts below 10 CFU/cm^2 and of *Enterobacteriaceae* below 1 CFU/cm^2 are acceptable. Hence, we conclude that on cleaned boards, the counts observed and listed in Table 1 are acceptable.

4 Conclusions

The experiments performed both in the laboratory kitchen (with three different cutting boards) and in the bistro (with maple board) showed no significant differences in microbiological counts on wooden and plastic cutting boards after proper cleaning. The overall hygienic status of the examined boards was good and classified as acceptable. We found no evidence for an increased microbiological risk when properly maintained wooden cutting boards are used at home or in gastronomic units. Nevertheless, cleaning procedures (hand wash vs. use of dishwasher) should be always adjusted according to the material of the boards. Hence, the instructions of the manufacturers on cleaning and maintenance should be followed, to ensure optimal performance and safety of the food preparation.

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