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Comparison of Various Types of Cutting Boards in Bacterial Contamination

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ABSTRACT

The goal of this research was to compare contamination rates or recovery of bacterial contaminations on four types of cutting boards (CBs). Total plate count was performed after applying food for 15 minutes.

The contamination of plastic boards was greater than wooden CBs for meat and chicken. On the contrary ,application of vegetables showed contamination rate on wooden more than plastic boards. Results also indicated high contamination rate on glass CBs of chicken. Finally stainless steel showed the same degree of contamination with respect to the three types of food applied.

Experimental contamination with *E.coli* and *Salmonella* spp. interestingly revealed that contaminated wooden boards with *E.coli* gave a recovery of less than half the CFU in the control after 5 minutes, and growth was ceased after 15 minutes. Contamination of wooden CBs with *Salmonella* spp. showed a decrease of CFU after 5 minutes. On the other hand, plastic boards had a high recovery rate after 5 minutes. Results of this study strongly recommends using wooden CBs for a more safe and hygienic nutrition.

Keywords: Cutting boards, Total count, Experimental contamination, *E.coli*, Salmonella spp.

مقارنة التلوث البكتيري لأنواع مختلفة من لوحات القطع

الملخص

أجريت مقارنة بين أربعة أنواع من لوحات القطع لدراسة التلوث الجرثومي لها من خلال تحديد العدد الكلي للجراثيم بعد وضع مادة غذائية معينة عليها لمدة 15 دقيقة. أظهرت النتائج ان لوحة البلاستك احتوت على تلوث اكثر من لوحة الخشب بعد وضع نوعي الغذاء –اللحم والدجاج– وبالنسبة للخضراوات فكانت النتيجة معاكسة للبلاستك. اما فيما يخص لوحة الزجاج فقد كانت نسبة التلوث عالية للدجاج وكانت النسب متقاربة للأغذية الثلاث عند استخدام لوحة القطع من نوع الستيل. كما تم اجراء تلوث تجريبي للوحات القطع ببكتريا *E. coli* و*Salmonella* spp. و النتيجة المهمة كانت في عدد المستعمرات الناشئة بعد تلويث لوحة الخشب ببكتريا *E. coli* اذ اختزل عدد المستعمرات بعد مرور5 دقائق الى اقل من النصف وانعدم تماما بعد 15 دقيقة من التلويث التجريبي. أما بالنسبة لجرثومة *Salmonella* spp. فقد اجري التلوث التجريبي على كل من لوحتي الخشب والبلاستك والنتيجة كانت حدوث انخفاض كبير في عدد المستعمرات بعد مرور 5 دقائق على فترة التلويث للوحة الخشب، أما البلاستك فبقيت محتفظة بالتلوث بشكل كبير بعد مرور5 دقائق على التلويث. نستنتج من هذه التجربة ان لوحة الخشب هي افضل من لوحة البلاستك ويوصى باستخدامها في المطابخ لتغذية صحية اكثر كونها لا تحتفظ بالبكتريا لمدة طويلة على سطحها.

INTRODUCTION

The traditional surfaces on which food has been prepared for centuries has been wood, then in the last few years various polymers have become available as cutting boards (CB). There was study

mentioned that the USDA recommended plastic CB, it seemed the logical, reasonable choice. After all, plastic is nonabsorbent and easy to clean, presumably making it less likely to harbor bacteria and other microorganisms on its surface than wood is. But this recommendation was never based on evidence from scientific tests, after that two groups came up with exactly opposite conclusions. The first group was a team of microbiologists from the university of Wisconsin, they experimented with hardwood chopping blocks and plastic boards inoculated with pathogens such as *Salmonella*, *Escherichia coli*, and *Listeria monocytogenes*. One of the most unexpected results was that the wooden boards actually killed 99.9% of the bacteria within a few minutes. The team concluded from the lack of viable cells that wood must contain some antibacterial substances, although they were unable to isolate them. The plastic boards did not similarly reduce the numbers of pathogens and they failed to live up to expectations in other ways, the other group was researchers from the Food and Drug Administration who performed an electron microscope study of wood. They found that pathogens such as *E. coli* and *Campylobacter* became trapped in the porous spaces of wood boards and were able to survive for 2 hours to several days, depending on the moisture content of the wood. They continue to recommend the use of plastic because bacteria trapped in wood would be difficult to remove and could be released during use (Cowan and Talaro, 2006).

The CB was selected because it has been shown that when CBs become contaminated, pathogens can survive and multiply on the surfaces, and are readily transferred to other surfaces in sufficient numbers to represent an infection hazard (Cools *et al*., 2005). Furthermore, the CB is one of the top five sites most contaminated with heterotrophic bacteria in the kitchen and may facilitate transmission of foodborne pathogens by cross-contamination (DeVere and Purchase, 2007). So the first objective of this study was to determine the degree of contamination on different types of CBs, and the second was to make experimental contamination of these CBs with pathogenic bacteria to achieve the major aim that is which type of CBs is better choice for food safety.

MATERIALS AND METHODS

The locations selected for sampling were the CBs because of contact surfaces that may facilitate cross contamination. Four Types of CBs were used include: wood, plastic, glass ,and metal (stainless steel). And Three types of food were taken for the scan of CBs contamination include: minced (chopped) meat, raw chickens, vegetables (Table 1).

Table 1: Food samples distributed on four type of cutting boards*

Food samples	Wood CB	Plastic CB	Glass CB	Stainless steel CB
Chopped meat	16	18	8	10
Chicken	2	2	2	4
Vegetables	12	10	16	6

***:** Numbers in the table represent the numbers of samples as obtained.

1- The Total count: The enumeration of total aerobic mesophilic plate count were done to show the degree of contamination that is handled in the CBs. Sampling was taken after the CBs were washed with ethyl alcohol (70 %), then after air drying the mentioned food samples were left on the CBs for 15 minutes then sampling procedure was done by taking sterile cotton swabs, the swabbing was done with a pencil eraser-type pressure with horizontal, vertical and diagonal ways over the surface

then moistened in tubes containing 4 ml of Nutrient broth (Leboffe and Pierce, 2011). The samples were diluted 10 fold up to 10^{-2}, then 100 µl of the bacterial suspension using nutrient broth tubes was pipetted on a Petri dish containing nutrient agar (Oxoid) by spreading method then the plates were incubated at 37º C for 24 hours. After the incubation period has finished, all the colonies on the plate were considered for the enumeration.

2- Experimental contamination: new CBs of four types were used. Its surface was sampled by the modified "agar sausage" method as will see below. The Plastic and wood boards were cut into 5-cm square blocks (area 25 cm^2), Pieces of board were selected randomly for each experiment, but lines were drawn on glass and stainless steel boards with 25 cm^2 area (they had not been cut), 0.5 ml of the inoculums (cultures of *E.coli* and *Salmonella* spp. obtained from Biology department/ College of Science/ Mosul University had been grown overnight at 37º C in nutrient broth) was diluted 10 fold up to 10^{-6} then deposited on the upper glass and stainless steel boards and blocks surface of plastic and wooden CBs, and spread with the side of the pipet.

According to (AK *et al*.,1994a), in "agar sausage" surface sampling technique, nutrient agar medium was sterilized in plastic cylinders made from autoclavable 60-ml syringes, 2.54 cm diameter, by cutting the end from the barrel. The agar surface (25 cm^2 area) was raised past the end of the barrel by pushing the plunger, pressed against the test surface, sliced off with a sterile knife and transferred into a petri dish.

Another method was used by pressing a block directly onto the surface of nutrient agar in a petri plate (applied so as to avoid trapped air and pressed gently for 2 min.). The contamination level was determined by control culture which was prepared as the same experiment dilution, that has poured directly in medium and was counted after 24 hours in incubation at 37º C. Sampling intervals after contamination were typically 5 and 15 minute, the incubation period was 24-48 hours at 37º C.

RESULTS AND DISCUSSION

This research was focused on the CBs because these surfaces are major sources of cross contamination referring to the microbiological performance.

Various studies have demonstrated that the main sources of cross contamination during processing come from food contact surfaces, equipment and employees (Fuster-Valls *et al*., 2008).

Equipment and surfaces can be source of direct contamination when they have not been effectively cleaned or remained wet between cleaning and use (Evans *et al*., 2004). Food handlers have a major role in the prevention of foodborne diseases since they may cross contaminate raw and ready-to-eat food, and be asymptomatic carriers of food poisoning microorganisms (Walker *et al*., 2003).

The study was performed to estimate the total aerobic bacterial count recovered on four types of CBs following exposure to three types of food. Prevalence of bacteria on wooden CBs gave the highest rate 36.23% after subjecting it to meat, followed by chicken 34.55%, and vegetables 29.20% as shown in (Fig. 1). Plastic boards demonstrated very close prevalence rates in the case of meat and chicken 39.198 % , 40.99% respectively, and 19.8% after applying vegetables, (Fig. 2). On glass CB, results showed a high prevalence of contamination rate 52.20 % following application of chicken. On the contrary, meat declined to 30.12% and as for vegetables the rate was shown to be 17.67% (Fig. 3). Finally, the present study indicated contamination rates on stainless steel CBs of 35.11 %, 31.55 % and 33.33% for meat, chicken and vegetables respectively (Fig. 4).

Experimental contamination using "agar sausage" was carried out with *E.coli*, and *Salmonella* spp. (Table 2). For *E.coli*, the initial number of CFU was 83. The number of CFU declined on both wood and stainless steel CBs to 30 and 48 CFU respectively after 5 minutes to zero CFU after 15 minutes. Recovery of *E.coli* on plastic surfaced CB showed 53 CFU after 5 minutes, 17 after 15 minutes. Finally, glass CBs demonstrated the highest recovery of CFU indicated by 65, and 54 CFU after 5 and 15 minutes respectively.

Salmonella was clearly affected by wooden boards after 5 minutes as it gave a count of 20 CFU when compared with 140 colonies in the control plate, similarly no growth was found after 15 minutes. On plastic boards, no large decrease was noticed in the number of bacteria after 5 minutes, 120 CFU were found and 60 colonies at the end of 15 minutes. The results of the present study suggested that wood inhibited the growth of bacteria and thus wooden CBs were the safe to use.

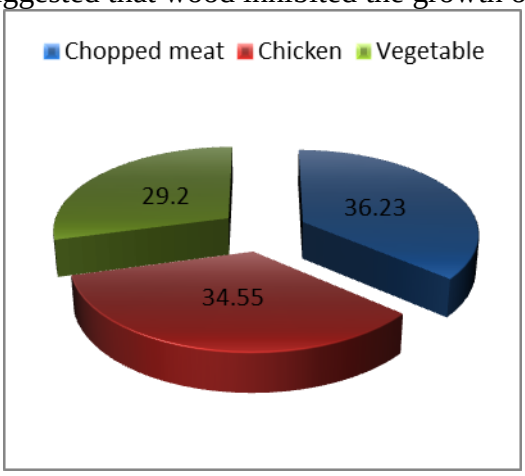

Fig.1: The percentage of CFU average obtained from wood cutting boards

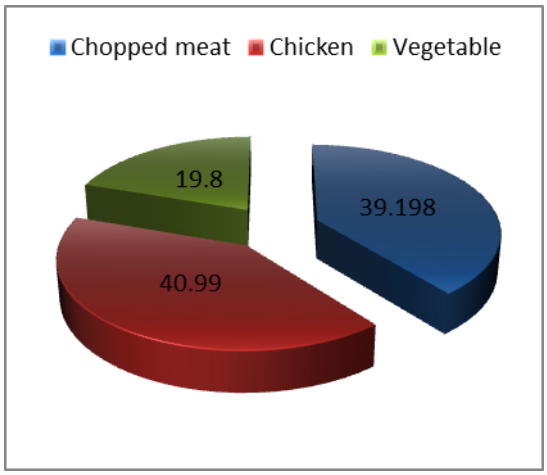

Fig.2: The percentage of CFU average obtained from Plastic cutting boards

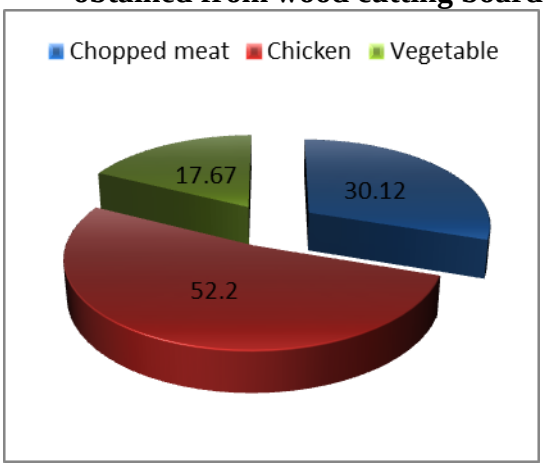

Fig.3: The percentage of CFU average obtained from Glass CBs

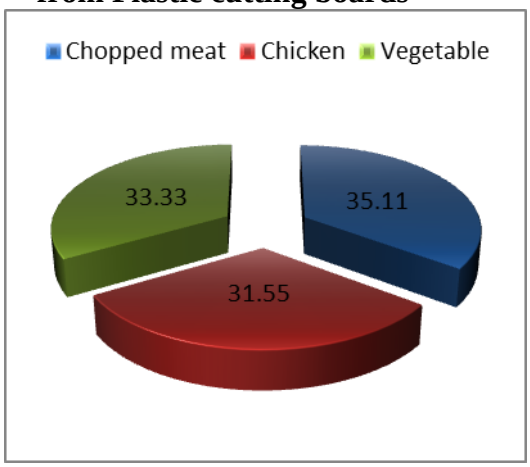

Fig.4: The percentage of CFU average obtained from Stainless steel CBs

Table 2: Experimental contamination with *E.coli* for four CBs and *Salmonella spp.* for wood and plastic boards

Bacteria / Cutting Board	*E .coli* Initial CFU = 83		*Salmonella* Initial CFU =140	
	After 5 min. CFU (decline %)	After 15 min. CFU (decline %)	After 5 min. CFU (decline %)	After 15 min.CFU (decline %)
Wood	30 (64 %)	0 (100 %)	20 (86 %)	0 (100 %)
Plastic	53 (36 %)	17 (80 %)	120 (14 %)	60 (57 %)
Glass	65 (22 %)	54 (35 %)	–*	–
Stainless steel	48 (42 %)	0 (100 %)	–	–

* : Not done

The accurate detection and enumeration of microbial contamination using the traditional swabbing technique relies initially upon the ability of the swab to remove the microorganisms from the surface, followed by their effective release from the swab bud and their subsequent recovery (Moore and Griffith, 2002). Furthermore, the degree of microbial adhesion and survival on a surface is influenced by many factors, such as material geometry, porosity, roughness, composition, hydrophobicity, temperature and moisture (Williams *et al*., 2005)

Ak *et al.*, (1994a; 1994b) showed that wooden CBs and plastic CBs were comparable and perhaps, that wood was better in terms of the number of contaminating microorganisms that could be recovered from the surface after cleaning. They used conventional cleaning methods and conventional microbiological surface recovery methods, and showed that both surfaces could be contaminated if not cleaned correctly or could be cleaned virtually free of recoverable microorganisms. It is important to say "recoverable" because both wood and plastic surfaces are porous, and microorganisms can be absorbed into the material where they may be viable for a time before they die.

Other research mentioned that wooden cutting boards would be almost as safe as plastics, bacteria such as *Escherichia coli* O157:H7 and Salmonella, which might contaminate a work surface when raw meat was being prepared, ought not remain on the surface to contaminate other foods that might be eaten without further cooking, so that disease from bacteria such as these were not recoverable from wooden surfaces in a short time after they were applied, unless very large numbers were used (Galluzzo and Cliver, 1996). New plastic surfaces allowed the bacteria to persist, but were easily cleaned and disinfected. However, wooden boards that had been used and had many knife cuts acted almost the same as new wood, whereas plastic surfaces that were knife-scarred were impossible to clean and disinfect manually, especially when food residues such as chicken fat were present, Scanning electron micrographs revealed highly significant damage to plastic surfaces from knife cuts. (AK *et al*., 1994b).

Kass, (1992) mentioned that a case-control study of sporadic salmonellosis had been done in CBs among many risk factors assessed although the bacteria that have disappeared from the wood surfaces are found alive inside the wood for some time after application, they evidently do not multiply, and they gradually die. They can be detected only by splitting the wood or by forcing water completely through from one surface to the other. If a sharp knife is used to cut into the work surfaces after used plastic or wood has been contaminated with bacteria and cleaned manually, more bacteria are recovered from a used plastic surface than from a used wood surface (AK *et al*.,1994b)

There are food preparation surfaces made of glass or of stainless steel; it has done very little with these because they are quite destructive of the sharp cutting edges of knives, and therefore introduce another class of hazard to the kitchen, all boards should be scrubbed with soap and hot water and disinfected between uses, especially if meats, poultry, or fish have been cut on them. Plastic boards should be replaced if their surface has become too roughened with use, and wooden boards must not be left moist for any period of time (Cowan and Talaro, 2006).

The effect of the difficulty to clean wooden type CBs in comparison to plastic type CBs due to the physical structure of wood which can absorb moisture and retain bacteria has been found in other studies (Deza *et al*., 2007).

The hypothetical concern, at least in home kitchen ,was and is cross-contamination. Residues of fluid (juice) from raw meat or poultry might remain on the work surface and transfer disease agents to raw vegetables or other foods that would not be cooked further before being eaten. And some of the bacteria might multiply on the surface between being deposited from the first food and contaminating another. The transmitted bacteria of animal origin are significant causes of human infectious disease (zoonoses) (AK *et al*., 1994a).

Some Food Service Establishments (FSE) have single-purposed CBs, distinguished by colours, to use for a specific food type, that are cleaned at the end of the shift. The others of the FSE have multi-purposed cutting boards used for all the food types, that are cleaned after each use to avoid cross contamination (Walker *et al*., 2003).

CB is considered as a critical source of cross contamination according to other studies that have found contamination with *Campylobacter* and *Staphylococcus aureus* microorganisms coming from hands. Hands can contaminate food through residential flora of the skin e.g. micrococci, staphylococci, propionic bacteria and corynebacteria; and the transient flora such as fecal pathogens like *Escherichia coli* and Salmonella (Aarnisalo *et al*., 2006). So, the cleaning and disinfection procedure is important to consider because inadequate cleaning and disinfection of food contact surfaces represents a risk factor for cross contamination because of the possible presence of pathogens that have low minimum infective dose such as *Escherichia coli* O157:H7or *Listeria* spp. and because is an effective means to reduce cross contamination and the occurrence of foodborne outbreaks (Watchel *et al*., 2003; Gibbons *et al*., 2006). It has been found that rinsing with water and domestic chemical cleaners does not ensure total elimination of bacteria from CBs (Watchel *et al.*, 2003), and antimicrobial agents are necessary to achieve complete hygiene of the surfaces (Schonwalder *et al*., 2002). The use of chlorine containing compounds has been found in other studies to be effective to reduce bacterial numbers to acceptable limits such as *Escherichia coli* which requiring short to moderate contact time (Williams *et al*., 2005).

The microbial quality of surfaces has been identified as a useful indicator for control of the critical points related to the procedures of cleaning and disinfection (Legnani *et al*., 2004). Furthermore, the microbial analysis of food contact surfaces may indicate the actual status of the hygienic design of equipment and facilities and actual specificity of the sanitation program (Jacxsens *et al*., 2009).

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