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The Role of Pallets in Microbial Food Safety

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ABSTRACT

Pallets play an important role in food transportation but are seldom in direct contact with food and are not intended to be used in contact with food. We have surveyed information relevant to the possible influence of wood versus plastic pallets on food safety. Wood absorbs bacteria, which cannot later be recovered alive at its surface. Bacteria do not penetrate below the surface of new plastic and can be transferred to other surfaces. Scars on used plastic tend to harbor bacteria, which persist in a viable state. The choice of wood versus plastic pallets seems likely to have only a slight effect on food safety, but bacteria appear to be less easily transferred from wood than from plastic.

INTRODUCTION

Unintentional transfer of microbes from one surface to another is a means of spreading foodborne disease. The physical interactions between bacteria and a given material will influence the degree to which the microbes can be transferred from that material. Growth potential of the bacteria while attached and ease of removal are relevant factors in the consideration of cross contamination. Also important are the environments and processes to which the material and microbes are subjected during the period of physical interaction.

Pallets are characterized as tertiary packaging for purposes of food conveyance. Pallets come into contact either with packaging that contains food or with packaging that contains packages of food. In either case, pallets are often exposed to environments that are less sanitary than areas where food is packaged and prepared. It would be impractical, if not impossible, to maintain sterility while pallets are being used in every segment of the food supply chain, such as in transit in trucks and trailers. Therefore, the transferability properties of microbes from pallet construction materials are of interest.

Wood and plastic (polyethylene or polypropylene) are the two most widely used materials for pallet construction. Wood is by far the more common of the two and therefore has a longer record of safety in transport of food products. Although plastic has not been used as widely as wood, nestable plastic pallets have been popular in the grocery industry for over two decades. Recent publicity highlighting contamination of wooden pallets when used in unsanitary environments seems to imply that wood as a pallet construction material somehow exacerbates the risk of cross contamination. The possibility that a plastic pallet handled under unsanitary conditions will be safer than wood under the same conditions needs to be considered. A review of the existing scientific literature on the subject does not support this supposition.

The few studies that have directly compared wood and plastic in their potential for harboring and transferring bacteria have led to the conclusion that little practical difference exists, but if there is a difference, wood is less likely to serve as an inadvertent transfer medium *(6)*.

1. The number of bacteria that are recoverable from wood surfaces decreases within minutes of inoculation *(3)*. Bacterial colonies stay on the surface of plastic and actually grow if there is a sufficient supply of nutrients *(10)*.

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TABLE 1. Recoveries (Relative Light Units) of *E. coli* from cutting board surfaces washed 60 min after inoculation *(10)*

Comparison	Material	*E. coli* recovered[1]
Among wood species	Birch	2,753
	Maple	2,863
	Oak	1,785
Among plastics	Foamed polypropylene	7,605
	High-density polyethylene	4,621
	Polystyrene	3,117
Wood versus plastic	Maple	3,200
	High-density polyethylene	2,277
	Foamed polypropylene	5,315

Data are averages of triplicate samples from one trial. Number of cells applied, (1.0×10^6 CFU, or 5.0×10^4 RLU).
Std. Error: ± 5%

2. When they penetrate into a wood matrix, bacteria do not grow, but rather die in a matter of hours *(10)*. The hygroscopic nature of wood, as well as the presence of secondary metabolites (tannins, lignin, flavonoids and, in the case of the pine family, terpenoids) directly inhibits the growth of bacteria *(11)*.
3. Bacteria within a lacunar network of scraped and gouged plastic do multiply *(10)*; the inevitable crevices on the surface of a used plastic pallet could well act as miniature havens for bacterial culture.
4. Ground wood powder or shavings has been shown to inhibit bacterial growth; ground plastic powder did not *(10, 11)*.
5. Pine wood has a significantly greater inhibitory effect than other wood species tested *(11)*.
6. The overall message from published literature reviews is that there is no advantage of plastic over wood in regard to food safety *(5)*; if there is a difference, wood is safer than plastic.

RECOVERY

Direct comparisons between several types of used wood and plastic cutting boards *(10)* showed that after washing with detergent, recovery of *E. coli* was slightly higher from plastic than from wood (Table 1). Blocks were washed with detergent 60 min after inoculation; levels of live bacteria in swab samples were measured by ATP bioluminescence, using a *GEM Biomedicals* BG-P Optocomp 1 luminometer (Hamden, CT) and *GEM Biomedicals* ATP Surface Hygiene Monitoring Kit (Sparks, NV).

In another set of experiments, carving knives were used in their normal cutting function, to determine whether bacteria beneath the surface could be recovered in this way (Table 2). Some of the inoculated block surfaces had been washed before recovery was attempted. Ak *(2, 3)* and her colleagues found that following inoculation of bacteria onto wood surfaces, recoverability of the microbes decreased significantly over the course of 3 to 60 min. During these experiments, bacteria were found inside the wood but did not multiply, and they were affected by an apparent antibacterial action of the wood, common to all of the species tested. This result was basically the same for new and used wood. However, scratches and grooves in used plastic cutting boards tended to harbor microbes even after washing.

Schönwälder *(11)* examined survival of *Escherichia coli* and *Enterococcus faecium* on wood of several tree species and on polyethylene. Using agar contact plates placed on the test surfaces at various times after inoculation, they found a significant difference in bacterial recoveries from wood versus plastic. The number of recoverable bacteria decreased over time on both surfaces, but the decrease was faster on wood. Pine was the fastest, followed by beech, and finally plastic.

In a second set of experiments, wooden blocks were submerged for 15 min in bacterial suspensions. The inoculum was absorbed to different degrees by the different types of wood. When the blocks were cut and inner surfaces tested, it was found that the inner portions of pine reduced viability of the bacteria. After 7–8 h, no bacteria could be cultured from the inner surfaces of unwashed pine blocks. From blocks of beech and poplar, levels of bacteria could be cultured over a 24-h period.

In a third set of experiments, the effect of wood age was tested with boards taken from pallets used since 1987, 1994, and 1996. The bacterial reduction effect over time was consistent and independent of wood age.

The authors attributed the antibacterial properties of wood to two factors: First, the hygroscopic nature of dried wood lowered the amount of moisture available to the bacteria. Second, the fact that bacterial recovery from pine was lower than from beech, poplar, or spruce was interpreted as being due to tannins, which are natural wood preservatives.

TABLE 2. *E. coli* recovered (Relative Light Units) from knife edges after cutting into used boards that had been washed, or not, 60 min after inoculation[1] *(10)*

Board material	Unwashed	Washed
Maple	476	368
High-density polyethylene	7,896	555
Foamed polypropylene	9,625	2,433

[1]*E. coli* levels on used maple and plastic cutting boards inoculated with 10^6 CFU/25 cm^2, dried, sampled on knife edges before or after washing.

REVIEW OF RELEVANT STUDIES

A bibliographical review of the subject by Carpentier *(5)* notes the variability in techniques used among studies and the inconsistent consideration of factors such as types of wood used, times between inoculation and evaluation, orientation of wood fibers, humidity levels, and surface state of wood. He concludes by stating that he has not found "in the existing literature, any real demonstration of the superiority of plastic."

Tests with ground beef

Aged ground beef patties were used by Miller et al. *(9)* to contaminate wood and plastic cutting boards. Patties were held in contact with cutting board material for up to 90 minutes at room temperature. Attachment and removal of beef bacteria on polyethylene and wooden cutting boards were statistically indistinguishable.

Miller et al. *(9)* did find that aqueous extracts of white ash dramatically inhibited recovery of *E. coli*. Slight inhibition of growth was observed from extracts of black cherry and red oak. Pine was not tested in this study. The key point made in this study was that regardless of the surface material, cutting boards need to be constantly maintained and monitored for cleanliness.

Tests with fluorescent powder

Snyder *(12)* compared adsorption of fluorescent powder onto used wood and plastic boards. The powder particles were 5 µm, approximately the size of bacteria. The powder was applied in an oil suspension and spread with a paper towel. After application of the powder, the boards were washed with Dawn® detergent and scrubbed with a brush under flowing 100°F water.

After the boards were washed and dried, the accumulation of fluorescent material was much greater on the polyethylene cutting board than on any of the wooden boards. The non-hygroscopic nature of the polyethylene and the absence of tannins or other antimicrobial compounds would allow bacteria within these grooves to attach and multiply.

SUMMARY

Approximately 1.9 billion pallets are used daily in the United States, and about 90 to 95% of those pallets are made of wood *(8)*. Of those wooden pallets, about 40% are used to ship food items, including dry groceries, dairy, frozen foods, and fresh fruit and vegetables. The large number of food/package/platform interactions that take place without incident attests to the general safety of the materials and processes of production and distribution. Nevertheless, any reasonable opportunity to reduce the potential for foodborne illness should be considered.

Food processors and distributors need to be vigilant in maintaining effective sanitation practices. Poor hygiene is unacceptable when working with primary food packaging, secondary containers, or tertiary platforms.

The potential increase in plastic pallet use in the food industry may seem to some as an opportunity for more hygienic distribution. Until 1994, comparisons between wood and plastic for bacterial retention and transmission were generally interpreted as favoring plastics *(1, 4, 7)*. More recent scientific findings, however, suggest the opposite interpretation. Bacteria are able to grow on plastic surfaces and subsequently be transferred to other surfaces. The evidence shows that bacteria are less likely to grow on wood surfaces and that they are less easily transferred from wood. The apparent conclusion is that if a hazard exists, the hazard is from plastic pallets.

REFERENCES

1. Abrishami, S. I., B. D. Tall, T. J. Bruursema, P. S. Epstein, and D. B. Shah. 1994. Bacterial adherence and viability on cutting board surfaces. *J. Food Safety* 14:153–172.
2. Ak, N. O., D. O. Cliver, and C. W. Kaspar. 1994. Cutting boards of plastic and wood contaminated experimentally with bacteria. *J. Food Prot.* 57:16–22.
3. Ak, N. O., D. O. Cliver, and C. W. Kaspar. 1994. Decontamination of plastic and wooden cutting boards for kitchen use. *J. Food Prot.* 57:23–36.
4. Bartels, H., H. J. Klare, H. P. Woehner, and W. Hosper. 1973. Suitability of plastic cutting boards for meat processing plants. Fleischwirtschaft 53:1071–1072 (In German).
5. Carpentier, B. 1997. Sanitary quality of meat chopping board surfaces: a bibliographical study. *Food Microbiol.* 14:31–37.
6. Cliver, D. O. 2006. Cutting boards in *Salmonella* cross-contamination. *J. AOAC Int.* 89:538–542.

7. Gilbert, R. J., and H. M. Watson. 1971. Some laboratory experiments on various meat preparation surfaces with regard to surface contamination and cleaning. *J. Food Technol.* 6:163–170.
8. IBISWorld Inc. 2007. Wood container and pallet manufacture in the U.S. IBISWorld Inc., Santa Monica, CA. Publication No. 32192.
9. Miller, A. J., T. Brown, and J. E. Call. 1996. Comparison of wooden and polyethylene cutting boards: potential for the attachment and removal of bacteria from ground beef. *J. Food Prot.* 59:854–858.
10. Park, P. K. 1997. Microbiology of food contact surfaces vis-à-vis food safety. Ph.D. Dissertation, University of Wisconsin, Madison.
11. Schönwälder, A., R. Kehr, and K. Smalla. 2002. Wooden boards affecting the survival of bacteria? *Holz als Roh- und Werkstoff* 60:249–257.
12. Snyder, O. P. 2008. The evaluation of wooden vs. polyethylene cutting boards using fluorescent powder. http://www.hi-tm.com/Documents2008/cutboard-eval.pdf.