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# Understanding and Controlling Microbiological Contamination of Beverage Dispensers in University Foodservice Operations

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## SUMMARY

We have previously observed that beverage dispenser tips often contain high total microbial counts and are among the most contaminated surfaces found in foodservice establishments. The objective of this research was to determine the cause of these high microbial populations and find a practical solution to the problem.

Experiments were conducted on beverage dispensers in use in university dining halls as well as on an identical but new beverage dispenser located in our laboratory. Orange juice was dispensed through the various dispensers and total plate counts from the dispenser tips were measured at appropriate time intervals. Sanitizing solutions containing 100 and 200 ppm chlorine were used on beverage dispensers in dining halls, and subsequent microbial counts were observed throughout the following day.

Microbial counts tended to be highest immediately after a beverage had been dispensed and then declined gradually over time. Microbial counts from the new laboratory-based dispenser were initially low, but increased over time. Sections of the inside of the dispenser tip were observed with a fluorescent microscope, and results suggested the formation of biofilms. High microbial counts obtained by swabbing the inside of the dispenser tips were also consistent with the presence of biofilms. Sanitizing with a 200-ppm chlorine solution resulted in a greater reduction in microbial counts than with a 100-ppm solution. These results suggest that using a higher concentration of sanitizer may help reduce microbial counts on beverage dispenser tips.

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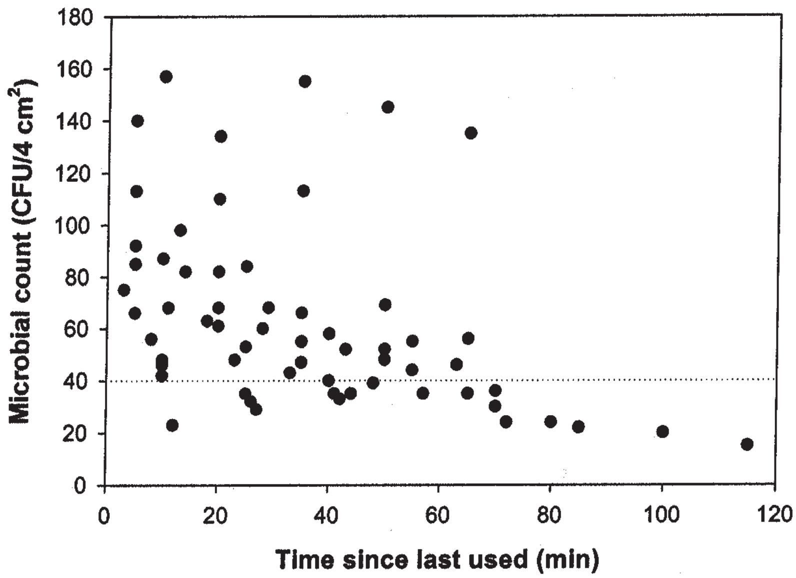
## INTRODUCTION

Microorganisms are present on many surfaces in foodservice operations *(3,7)* but juice dispenser tips are among those showing the highest total microbial counts *(3)*. Tips dispensing other beverages (e.g., acidic carbonated beverages such as cola) were less prone to contamination than were those dispensing fruit juices *(11)*. Although high total microbial counts alone do not indicate a food safety issue, they are an indicator of sanitation problems, and although all the juices served in Rutgers University dining halls are pasteurized and typically have bacterial counts of > 1,000 CFU/ml, unpasteurized juices have been the source of several foodborne illness outbreaks in the recent past *(10)*.

Proper surface sanitation in foodservice establishments is an important part of a food safety program. Sanitizer concentration and exposure time are two crucial factors in surface sanitation *(14)*. It is possible that microorganisms present on food contact surfaces have colonized those surfaces to form biofilms *(6, 13)*. Biofilms are a great concern in food processing *(9, 16)*, because cells in biofilms tend to have greater resistance to sanitizers than do planktonic cells *(12)*. Chlorine and chlorine compounds, commonly used as disinfectants in foodservice operations, are generally effective at controlling biofilms *(8, 9, 12)*. Increasing the

**FIGURE 1.** Relationship between time since the dispenser tip last used and microbial count observed in an orange juice-dispensing tip. The program guidelines for maximum contamination level for "in-use" surfaces (40 CFU/cm$^2$) is shown by the dotted line.




chlorine concentration of a sanitizer generally helps to increase its biocidal effect on biofilms *(4)*.

Prior research in our lab has determined relative contamination levels for a variety of food contact surfaces in university dining halls *(11)*. Sanitary guidelines established for food contact surfaces in Rutgers University dining halls also dictate that total microbial counts for an "in-use" surface should fall below 40 CFU/4 cm$^2$ *(17)*. Because orange juice is the most widely consumed juice in the Rutgers University Dining Services system, and because prior research has shown that orange juice dispenser tips were among the dispenser tips showing the highest levels of contamination *(3)*, typically well above 40 CFU/4 cm$^2$, we chose to further investigate the causes of these high microbial populations as well as solutions for controlling this problem.

## MATERIALS AND METHODS

### Juice dispenser tip sampling

Each Escort III juice dispenser tip consists of three parts: the main housing and two small baffles which fit inside the housing. The two baffles fit together to form a cylinder, which slides into place inside the main housing. The baffles aid in mixing juice concentrate and water as the two fluids flow through the main housing. Only the lower end of the main housing is exposed to the environment, and it is this end which is sampled for the presence of microorganisms.

The sampling procedure followed protocols commonly used in our lab *(3)*. CON-TACT-IT® tape, a gamma-irradiated sterile tape commonly used in microbiological applications for surface transfer of bacteria and other microorganisms, was pressed onto the dispenser tip, and excess beverage liquid was shaken off. The tape was then pressed onto total plate count agar, and agar plates were incubated at 37°C for 24 hours prior to enumeration.

The dispenser tips were sampled for total microbial counts at predetermined time intervals (e.g., 5, 15, 30 minutes), while at the same time, use of the juice dispenser by dining hall patrons was also recorded. Experiments were typically conducted over an entire work day (~ 8 h).

### Contamination in a new dispenser

A new, unused juice dispenser was provided by the Rutgers University Division of Dining Services for research purposes. This juice dispenser was used and cleaned on a daily or weekly basis. Data on the microbial contamination of this dispenser over time was collected in a manner identical to that previously indicated.

### Microscopy

Representative colonies from agar plates were selected for microscopic observation. Colonies were transferred to glass slides and Gram stained. Slides were observed at 400× under oil immersion.

At the end of representative days of sampling, and before the juice dispensers were rinsed and sanitized, dispenser tips were removed from the dispensers and transported to the laboratory. The tips were then cut into small sections, stained with acridine orange and observed under epifluorescent microscopy, following the procedure of Hood and Zottola *(5)*.

### Dispenser servicing

Beverage dispensers are typically serviced by non-university (vendor) technicians twice a year. During servicing, electrical connections are checked and dispenser tips are replaced, but internal tubing is not replaced. Data were collected on one juice dispenser on the day immediately before and on one on the day immediately after servicing, using the dispenser tip sampling technique already described.

### Tip cleaning dispenser rinsing and sanitizing

The three pieces of juice dispenser tip, a mixing chamber that precedes the juice dispenser tip and an inlet tube that feeds the juice concentrate into the dispenser are the only parts of the juice dispenser that can be disassembled, scrubbed and cleaned with detergent. The other components of the dispenser, including all the internal tubing, must be "cleaned" without disassembling the unit. Dining hall personnel follow the manufacturer's directions to treat each unit. They use a sanitizing solution containing 100-ppm chlorine to sanitize beverage dispensers at the end of each service day. Prior to sanitizing, juice concentrate containers are removed from the juice dispenser and replaced with tap water. Tap water is used to flush residual juice concentrate out of internal tubing of the dispenser before sanitizing.

Experiments were conducted in which cleaning and/or rinsing and sanitizing the day before was conducted by dining hall personnel following typical practices and using the standard sanitizing solution containing 100-ppm chlorine. Additional experiments were conducted in which the juice dispensers and tips were cleaned and/or rinsed and sanitized by one of us (CL), using either the standard sanitizing solution containing 100-ppm of chlorine or a double strength sanitizing solution containing 200-ppm of chlorine.

**FIGURE 2.** Increase in microbial contamination over time on the tip of a new juice dispenser. The program guidelines for maximum contamination level for "in-use" surfaces (40 CFU/cm$^2$) is shown by the dotted line.

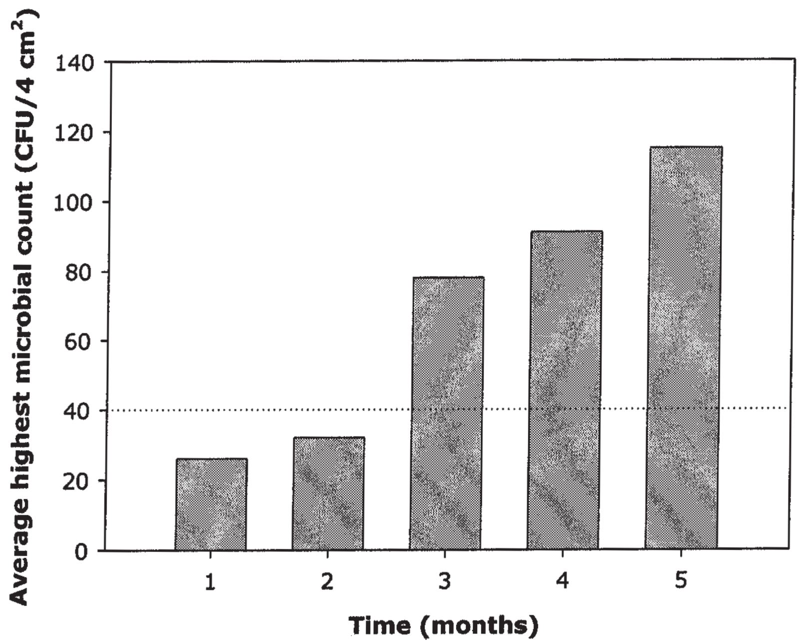
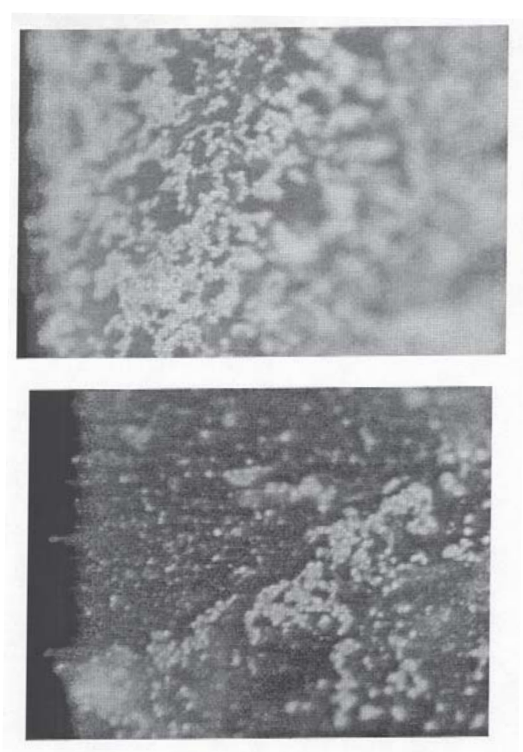



**FIGURE 3.** Acridine orange stained fluorescent microscopy images of the inner surfaces of an orange juice dispenser tip. Top panel: image from the inside of the dispenser housing. Bottom panel: image from an inner baffle.



## RESULTS AND DISCUSSION

### Dispenser tip contamination

Figure 1 shows the time since an orange juice dispensing tip was last used and the associated microbial counts during one typical day. As is evident, the microbial counts obtained throughout the day were regularly above the program guideline of 40 CFU/4 cm$^2$, shown by the dotted black line. It is also evident from Figure 1 that the microbial counts tend to be highest immediately after a beverage is dispensed, after which they decline over time.

Experiments done with different sampling time intervals, from 5 to 30 minutes, showed the same change in the rate of decline with time (data not shown). These data indicate that repeated sampling of the dispenser tip does not affect microbial counts obtained at later times.

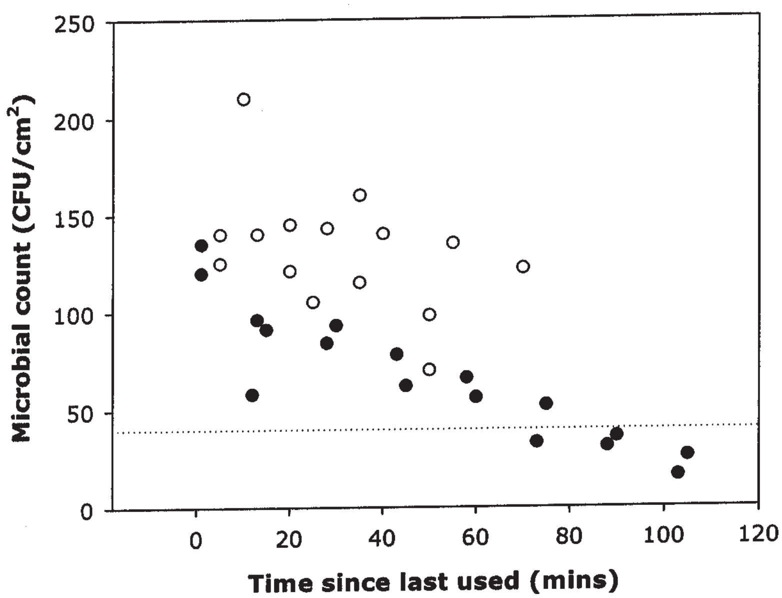
Immediately after a juice dispenser dispenses a beverage, a small portion of residual liquid remains on the tip. Because the dispenser tip is not refrigerated, an increase in microbial counts with time after each dispensing event might be expected, as the microbes present in the residual juice would begin to grow. Figure 1 shows that this is clearly not the case. It appears instead that, over time, the residual liquid starts to dry out. This may result in an inactivation of the organisms present or simply in a reduction in the likelihood of recovering those organisms because of the reduction in moisture content. It is known that the presence of moisture can facilitate microbial transfer between surfaces *(15)*.

The microbial count of Rutgers University dining hall orange juice, which is evaluated periodically *(11)*, averages less than 1,000 CFU/gm. The pH of orange juices dispensed in Rutgers University dining halls falls within the normal expected range of 3.3 to 4.1 Dispensing juice through a tip containing high microbial populations does not appear to significantly affect its microbial count. Estimates of the weight of juice remaining on a juice dispenser tip and weights of juice transferred to CON-TACT-IT® performed with an analytical balance indicate that virtually none of the CFU detected on a juice dispenser tip arise from the microbial concentrations found in juice concentrate.

### Contamination in a new dispenser

Figure 2 shows a summary of the data collected from the research juice dispenser. The data plotted against the y-axis represent the average highest count observed in each month, once the dis-

**FIGURE 4.** Effect of service on the microbial counts. Open circles represent counts before services, closed circles counts after servicing. The program guidelines for maximum contamination level for "in-use" surfaces (40 CFU/cm²) is shown by the dotted line.




penser had been placed in service in the lab. Average highest count represents the average of the highest 10% of all the counts observed in a given month. The average highest counts observed in the first two months after the dispenser was placed in service are within the program guidelines (40 CFU/$cm^2$, shown by the dotted line), although a slight upward trend is evident from month 1 to month 2. Months 3 through 5 all show average highest counts well above the program guidelines and a continued upward trend. Although the usage rate of the research juice dispenser was less than that of a typical dispenser used in a dining hall, the data for months 3 through 5 of the research dispenser closely approximates similar data obtained from juice dispensers in use in University Dining facilities.

The fact that microbial counts on a juice dispenser tip in a new dispenser increased with use and over time is consistent with the development of a biofilm inside the juice dispenser. Microorganisms tend to attach to surfaces that are in regular contact with liquids and form biofilms *(2)*. Biofilms may also cause biofouling, a term often used where the formation of biofilms is undesirable, e.g., impeding the flow of liquids, cross contamination, etc. *(8)*, although no evidence of impeded flow is evident in the case of the juice dispensers studied here.

## Microscopic observation and epi-fluorescence imaging

Microbial evaluation of colonies isolated from dispenser tips revealed the presence of yeasts and some gram-negative bacteria. Previous studies have also indicated that there are a wide variety of yeasts in orange juice *(1)*.

Persistent high microbial counts from the beverage dispenser tips, which tended to increase over time, suggested the possibility of biofilm formation. Figure 3 shows epi-fluorescent microscopy images of the inner surfaces of orange juice dispenser tips. Figure 3 — top panel is an image taken from the inside of the main housing. Figure 3 — bottom panel is from an inner baffle piece. Similar images (data not shown) were obtained from other inside surfaces of the juice dispenser tip assembly. Blurred edges are due to the curved nature of the solid surfaces, but the images are consistent with the presence of microbial biofilms on the inside of juice dispenser tip surfaces. Swab tests of the internal surfaces of the juice dispenser typically revealed high concentrations (> $10^4$ CFU/$cm^2$). It is interesting to note that although dispenser tips are the one location on a juice dispenser that are cleaned with detergent and physically scrubbed, biofilms still apparently develop.

## Effect of dispenser servicing on microbial counts

The marginal decrease in microbial counts after servicing is seen clearly in Figure 4. Although servicing does appear to have an effect on the sanitary quality of the juice dispenser tips, and although the range of counts observed after servicing (solid circles) is lower than before services (open circles), in many cases the microbial counts observed were well in excess of the program guidelines (dotted line). The nominal reduction and the reduced variability are most likely due to the discarding of the old dispenser tips and their replacement with new ones.

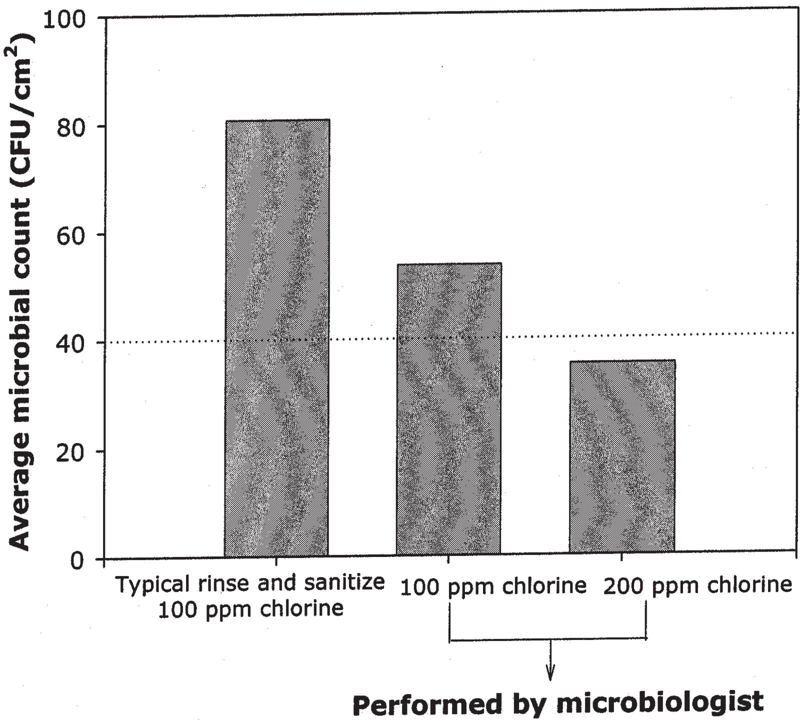
## Effect of sanitizer concentration

Figure 5 shows that typical sanitizing by dining hall personnel results in a juice dispenser that will not, on average, meet the guidelines for sanitary quality of surfaces laid out in the program *(17)*. Careful, deliberate rinsing and sanitizing by one of the authors (CL) resulted in an improvement, but the dispenser would still not meet our guidelines for sanitary quality of surfaces on average. When careful, deliberate rinsing and sanitizing was coupled with a doubling in strength of the sanitizing solution, this did result in a juice dispenser tip that would, on average, over the course of the next day, meet our guidelines for sanitary quality of surfaces. These results indicated that improved training for dining hall employees and an increase in the level of sanitizer routinely used are probably warranted.

# CONCLUSIONS

Our results indicate that microbial counts on juice dispenser tips are highest immediately after a beverage has been dispensed, after which counts tend to decline until the dispenser is used again. A new (previously unused) dispenser showed low average microbial counts in the first two months of use, but these microbial counts increased with time and use. In less than four months, counts in a new dispenser were comparable to those in dispensers in regular use in the dining halls. Examination of the inner surface of orange juice dispenser tips, by use of fluorescent microscopy, indicated possible biofilm formation inside them. Surface swabs of the internal surfaces of dispenser tips also revealed high counts consistent with biofilm formation. Servicing a dispenser (even after replacing old dispenser

**FIGURE 5.** The effect of juice dispenser rinsing and sanitizing on average microbial counts. The program guidelines for maximum contamination level for "in-use" surfaces (40 CFU/cm$^2$) is shown by the dotted line.




tips with new) did not significantly reduce microbial counts. Properly rinsing the juice dispenser and increasing the concentration of the sanitizer to the maximum level allowed (200 ppm chlorine) helped to reduce average microbial counts to acceptable levels.

Our results indicate that juice dispensers that are rinsed and sanitized may eventually develop juice dispenser tips that are highly contaminated with a variety of microorganisms. This contamination is consistent with the development of a biofilm on the internal tubing of the juice dispenser and the juice dispenser tip. Proper rinsing (following the manufacturer's directions) and sanitizing (with the maximum allowed level of sanitizer) may help to control but not eliminate the problem. Our results suggest that development of a true clean-in-place system, which uses detergent and some type of physical action, may better control biofilm development.

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