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A Research Note

Microbial Evaluation of Vegetable Ingredients in Salad Bars†

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ABSTRACT

Vegetable salad ingredients (lettuce, tomatoes, broccoli, and cauliflower) purchased from three grocery-store deli operations were analyzed for total plate count, coliforms, yeasts, and molds. The temperature of the vegetable ingredients was measured at the time of purchase and the pH was measured on all samples within one-half hour after purchase. In the second phase, fresh broccoli was processed into florets, inoculated with *E. coli* ATCC 23742, and subjected to three washing treatments.

The temperature of the salad ingredients ranged from 5.1°C to 18.9°C. The pH ranges for the vegetables were broccoli, 5.46 to 6.39; cauliflower, 5.82 to 6.65; lettuce, 4.92 to 6.38; and tomatoes, 3.30 to 4.47. The total aerobic count for the vegetables ranged from 5.51 to 6.63 log CFU/g. Coliforms on the vegetables ranged from 4.89 to 6.30 log CFU/g. Yeasts and molds were found on all vegetables. The results of the study indicate that the temperature conditions and pH ranges for the broccoli, cauliflower, and lettuce could support microbial growth. The pH range of the tomatoes was below 4.6, but if contaminated and added to low acid foods, the tomatoes may also act as a vehicle for microbial contamination.

When a chlorine wash solution was used, it slightly reduced the aerobic microbial load on previously inoculated broccoli and reduced the coliform population of the broccoli by approximately one log unit.

Key words: Salad bar, vegetables, microbial evaluation

The food safety of fresh produce available in salad-bar operations is a concern *(3)*. Salad ingredients may be extensively handled during preparation and service by food-service personnel, depending on the practice of the operation. This handling is a potential source of microbial contamination. Customers also handle salad ingredients in self-serve salad-bar operations, which may lead to additional contamination. In addition, salad-bar ingredients may be held for long periods of time under improper temperatures, providing food-borne microorganisms with appropriate conditions for growth. These ingredients are eaten raw; no heat treatment is used that would destroy microbial contamination. Gourama et al. *(2)* demonstrated that *Staphylococcus aureus* could grow in clam chowder and green pepper from a salad bar.

Disease outbreaks caused by consumption of contaminated fruits and vegetables occur less frequently than those caused by consumption of contaminated meat and poultry *(4,6)*. Recently food-borne illness outbreaks have been reported from vegetables/fruits contaminated with pathogenic microorganisms. Fresh produce processing is an emerging industry offering nutritious and convenient products for the consumer *(3)*. Deli operations provide retail groceries with an opportunity to compete with fast-food operations with a fresh, ready-to-eat product. The challenge is to provide a safe product with a longer shelf life. Extensive handling of salad-bar vegetables and temperature abuse provides opportunities for microbial contamination and growth.

The purpose of this research project was to survey the microbial level of vegetables selected from salad bars in grocery store/supermarket deli operations.

MATERIALS AND METHODS

Salad-bar ingredients

Three commercial grocery store/supermarket deli operations in Lincoln, Nebraska were randomly selected. Salad-bar ingredients (lettuce, tomatoes, broccoli, and cauliflower) were purchased based upon a random sampling schedule. The temperature of each vegetable was measured immediately after purchase. The salad ingredients were then placed in an insulated chest to maintain the temperature of the vegetables during transport. Upon arrival in the laboratory, the vegetables were visually assessed. A 1:4:: vegetable:distilled water sample was blended for 2 min and the pH was recorded 2 min after blending using an Accument pH meter (Fisher Scientific Co., Pittsburgh, PA).

Each vegetable was assayed for total aerobic plate count on plate count agar (Difco Laboratories, Inc., Detroit, MI) (PCA), for coliforms on violet-red bile agar (Difco), and for yeasts and molds on potato dextrose agar with 100 mg/l tetracycline (Difco) *(7)*.

Inoculation and washing

Fresh broccoli was purchased from the produce department of a local grocery store and prepared by cutting the heads into florets (approximately 1,000 g). *Escherichia coli* ATCC 23742 was used in this study. Stock culture were maintained on PCA slants (Difco). The inoculum was prepared by inoculating *E. coli* into brain heart infusion broth (Difco) and incubating at 37°C for 24 h. The culture was diluted

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TABLE 1. *Microbial evaluation, temperature, and pH of salad bar vegetables.*

	Broccoli	Cauliflower	Lettuce	Tomatoes
Samples examined (–)	36	36	36	36
Aerobic plate count (log CFU/g)	6.63	5.25	5.70	5.51
Coliforms (log CFU/g)	6.30	4.89	5.40	5.20
Yeasts/molds (log CFU/g)	8.38	7.07	6.78	6.26
Temperature range (°C)	6.5 - 16.2	6.1 - 14.5	8.7 - 18.9	5.1 - 16.6
Temperature avg. (°C)	11.7 ± 2.5	10.8 ± 2.0	12.8 ± 2.4	11.1 ± 2.6
pH range	5.64 - 6.79	5.82 - 6.65	4.92 - 6.38	3.30 - 4.47
pH avg.	6.12 ± 0.22	6.25 ± 0.19	5.66 ± 0.33	3.99 ± 0.28

with a phosphate buffer (10^5 CFU per ml diluent) and applied to the surface of the broccoli. The broccoli was then equally divided into three portions. One portion was not washed (control), the second was washed with sterile distilled water for 2 min, and the third was washed in a one liter solution of 50 ppm (mg/l) chlorine (Chlorox™)/ distilled water solution for 2 min. The broccoli portions were stored in containers which were set on a bed of ice to simulate a salad bar situation and held at room temperature. Broccoli samples were taken for analysis after 0, 2, and 5 h.

Statistical analysis

Means and standard deviations were obtained for each analysis (4 samples per vegetable by 3 stores by 3 replications) using the SAS program to conduct the statistical analysis *(5)*.

RESULTS AND DISCUSSION

Visual assessment of the vegetables upon purchase included wilted lettuce, wilted and yellowed broccoli, cauliflower with brown spots or areas cut off and tomatoes with black spots. One sample of broccoli was deemed unacceptable as it was mushy and emitted a strong sulfur odor which permeated the room. These undesirable sensory attributes of the purchased vegetables suggest that they were improperly handled, held too long, or may have been "salvaged" from the produce department.

The vegetables analyzed, results of the microbial analyses, temperatures and pH values are given in Table 1. Aerobic plate counts of $10^{5.25}$ to $10^{6.63}$ CFU/g were found on all vegetables. Coliforms also ranged from $10^{4.89}$ to $10^{6.30}$ CFU/g on these selected vegetables. Yeasts and molds were found on all vegetables ($10^{6.26}$ to $10^{8.38}$ CFU/g). All vegetables were held at temperatures higher than the recommended 4°C. Only the tomatoes had a pH below 4.6 where most pathogens are inhibited.

The number of total microorganisms and coliforms found on the vegetables surveyed in this study may be of concern. Madden *(4)* discussed potential sources of microbial contamination of fresh fruit and vegetables during growth, harvest, distribution, and processing, and food-borne illness outbreaks which have occurred due to contaminated produce. The vegetables for this study were randomly obtained from grocery store deli operations and handling conditions were unknown. Although specific organisms were not isolated,

TABLE 2. *Changes in aerobic microorganism and coliform populations as affected by three wash treatments on broccoli inoculated with* E. coli *which was then held at room temperature (21°C) for different times.*

Treatment and Time Held (hours)	Aerobic Plate Count (log CFU/g)	Coliforms (log CFU/g)
No wash		
0	4.90	3.60
2	4.61	3.73
5	4.79	4.08
Wash with distilled water		
0	4.86	2.91
2	4.81	2.58
5	4.85	2.51
Wash with chlorine solution		
0	4.74	2.46
2	4.62	2.65
5	4.68	1.94

these numbers may indicate that contamination and/or growth of existing microflora have occurred. The ambient temperature of the vegetables gives further evidence that the vegetables were not properly stored. Grocery store deli operations may purchase prepared vegetables from a supplier or they may prepare vegetables from their produce departments. Either activity involves considerable handling where contamination could occur.

The pH measurements of broccoli, cauliflower, and lettuce are within the pH range where most pathogens grow. Lower microbial counts would be expected on tomatoes due to the lower pH (average pH 3.99). The high counts on tomatoes indicate contamination from excessive handling or cross-contamination during preparation.

In the washing experiment, water or a chlorine solution was used to reduce the microbial load on the broccoli contaminated by inoculation with *E. coli*. The broccoli was then held in a container on a bed of ice at room temperature to simulate a salad-bar situation. Washing the broccoli in water

slightly reduced the coliform load on broccoli but had no effect on the aerobic microorganisms (Table 2). The chlorine treatment reduced the initial coliform load by approximately one log unit, whereas the aerobic microorganisms were only slightly reduced. Holding the broccoli at room temperature on ice maintained the microbial load throughout the time period (Table 2). Beuchat and Brackett *(1)* found similar results with whole and chopped tomatoes treated with a chlorine solution and held in modified-atmosphere packaging. They reported that mesophilic aerobic microorganisms and *Listeria monocytogenes* populations were not reduced with a chlorine treatment at either of the storage temperatures (10 or 21°C).

Further research is needed to determine specific pathogenic bacteria that may exist or survive on these vegetables and the effect of storage time and temperature on the survival of microflora, particularly pathogens, on vegetables under deli conditions.

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