Comparative Analysis of Bacterial Concentrations on Different Types of Produce

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Abstract

Vegetables are an essential part of a healthy diet, providing a rich source of vitamins, minerals, fiber, and antioxidants. To ensure their freshness and maximize their nutritional value, proper storage conditions are crucial. We aim to analyze samples of root vegetables collected from three distinct grocery stores, with the primary goal of comparing the bacterial concentrations present on each vegetable. The findings of this experiment will contribute to an understanding of contaminants found in different environments that produce is kept in. By comparing the bacterial concentration levels, consumers can gain valuable insights to make well-informed choices regarding their produce purchasing preferences.

Introduction

Fresh fruits and vegetables provide important nutrients and enhance overall health, which are just a few of their many health advantages. Annually, the incidence of produce-related outbreaks has demonstrated a notable increase of 12%, underscoring the growing concerns regarding microbial contamination and its potential impact on public health[1]. It is important to look at different factors such as the processing of the vegetables, as it can increase their susceptibility to contamination[1, 2]. Getting vegetables from a clean environment is important to ensure cleanliness of the produce. Therefore it is important to be cautious about correct handling, storage, and processing to maintain the safety and quality of produce while still taking use of the nutritional benefits of fresh produce[3, 4].

The process of cleaning and sanitizing root vegetables involves several steps and considerations. Cleaning involves removing soil and residues from products like fruits and vegetables, with steps varying based on the type of produce and its condition[4, 5]. Sanitizing is the treatment of food contact surfaces with a sanitizing solution to reduce microorganisms[5, 6]. Chlorine bleach and quaternary ammonium compounds are commonly used solutions[5]. Proper cleaning and sanitizing involves preparing sanitizing solutions and maintaining accurate concentrations. The effectiveness of sanitizers can diminish over time, requiring changes in solutions. Factors such as pH, water quality, and concentration affect sanitizing efficiency[5, 6]. Ultimately, the aim is to achieve a 5-log reduction in microbial contamination [6]. Ensuring they undergo proper sanitization can help mitigate the risk of contamination. Before transportation, vegetables should be cleaned and free from excessive soil or debris. Proper sanitization practices prevent the introduction of contamination that can affect the quality and safety of the produce.

Several environmental conditions must be met to ensure the cleanliness and freshness of the produce. Both carrots and potatoes are sensitive to changes in temperature. The ideal temperature for transporting carrots is around 32°F (0°C) with high humidity, while potatoes should be transported at slightly higher temperatures, around 45-50°F (7-10°C)[5, 7, 9]. Proper ventilation is crucial to prevent the buildup of moisture and ethylene gas, which can cause faster spoilage[7]. They should be stored in temperature-controlled conditions to prevent exposure to extreme heat or cold, which can lead to spoilage or deterioration [8].Proper packaging is also essential. Carrots and potatoes should be packed in sturdy packaging that provides protection against physical damage during transportation[8]. Mesh bags, crates, or ventilated containers are commonly used for both vegetables[8, 9]. Carrots and potatoes should be stored separately from fruits and vegetables that produce high levels of ethylene gas[9]. Timely transportation is crucial to minimize the time between harvest and arrival at the store[9]. This helps maintain freshness and quality while minimizing spoilage. Regular monitoring and quality checks during transportation can help identify any issues deviating from the desired conditions. Local guidelines for produce conditions may vary[6, 7, 9].

Ensuring the store keeps produce at ideal temperatures and conditions, and undergoes the proper cleaning protocols with sanitization can also help reduce bacteria contamination. Large stores tend to have misting machines as observed with Stores A and B. Smaller stores tend to keep produce in baskets out in the open without mist. This was seen with the carrots in each store. Although they were all too numerous to count, the plates from Store C were visibly more populous with colonies. This is likely due to the lack of refrigeration in the small store, whereas the other stores had refrigeration and mist to keep the carrots at their ideal temperatures.

The aim of the study was to compare the bacterial concentrations on different root vegetables to collect data on the conditions of different sized grocery stores, fostering a more informed approach towards choosing where to buy one's produce. We hypothesize that smaller grocery stores will have higher bacterial concentrations on their produce compared to vegetables from large stores.

Methods

In this experiment, the objective is to determine the microbial concentration present on two types of produce obtained from three grocery stores of different sizes, designated as Store A (large), Store B (medium), and Store C (small). Carrots and potatoes were selected for analysis.

Microbial samples were obtained using sterile cotton swabs. A separate swab was used for each produce item. The carrots and potatoes were collected straight from the grocery store without any subsequent cleaning. The swabs were rubbed across the surface of the root vegetables, and then placed into sterile test tubes with distilled water.

Samples were subjected to a two-fold dilution process with distilled water. Aliquots of 100 microliters from the diluted samples of 10^0 and 10^{-2} were evenly spread across Tryptic Soy Agar (TSA) plates in duplicate, followed by incubation at room temperature for 48 hours and enumeration.

Results and Discussion

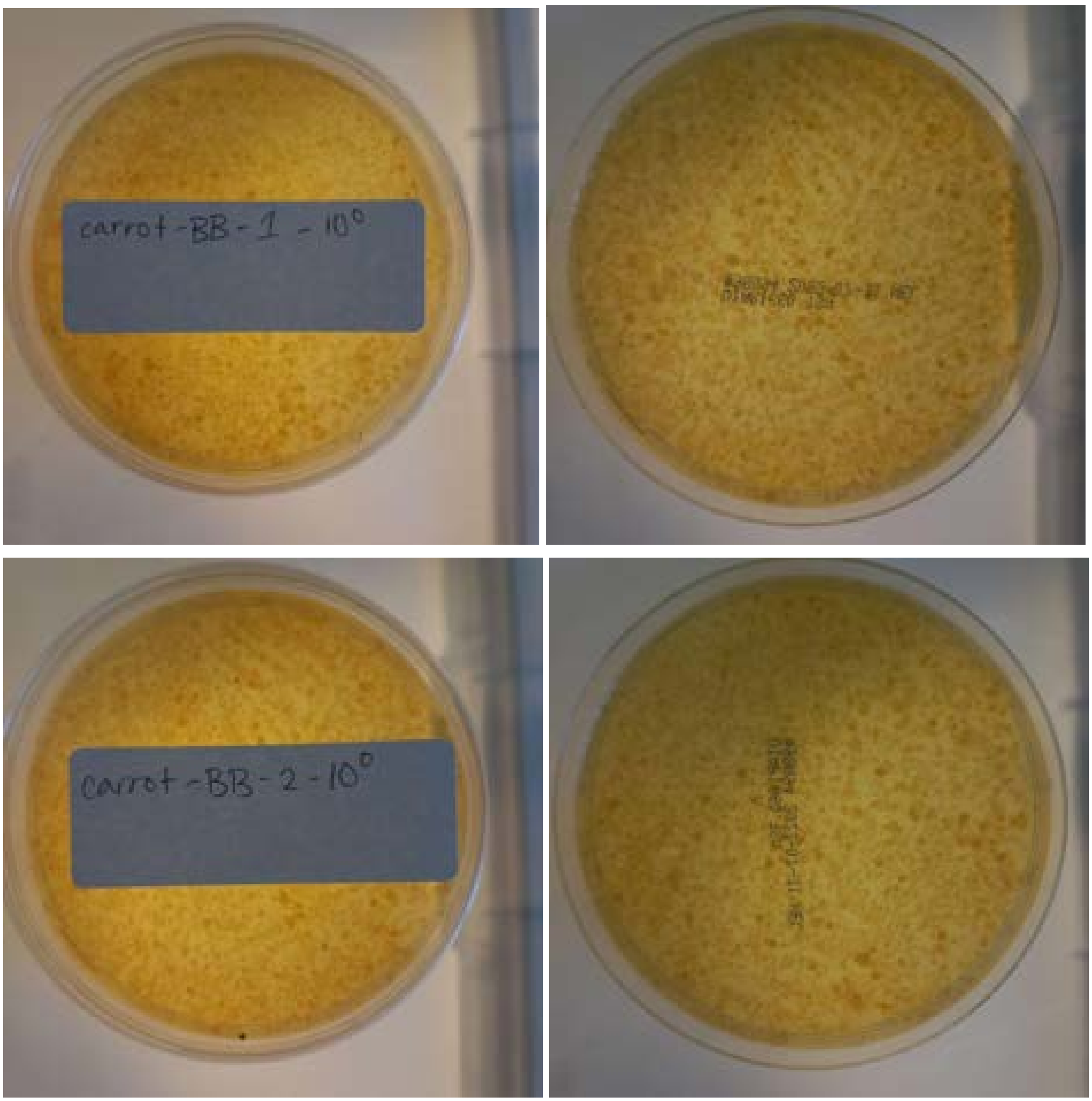
The bacterial concentrations of potatoes were notably consistent across all three grocery stores. The average concentration of potatoes from stores A, B, and C, were 8.42E+05, 3.06E+05, and 6.53E+04, respectively. Similarly, Pathak et. all (2022) reported an average concentration of 5.16 x 10^7 for potatoes [2].

Potato and Carrot CFU Count Data Table

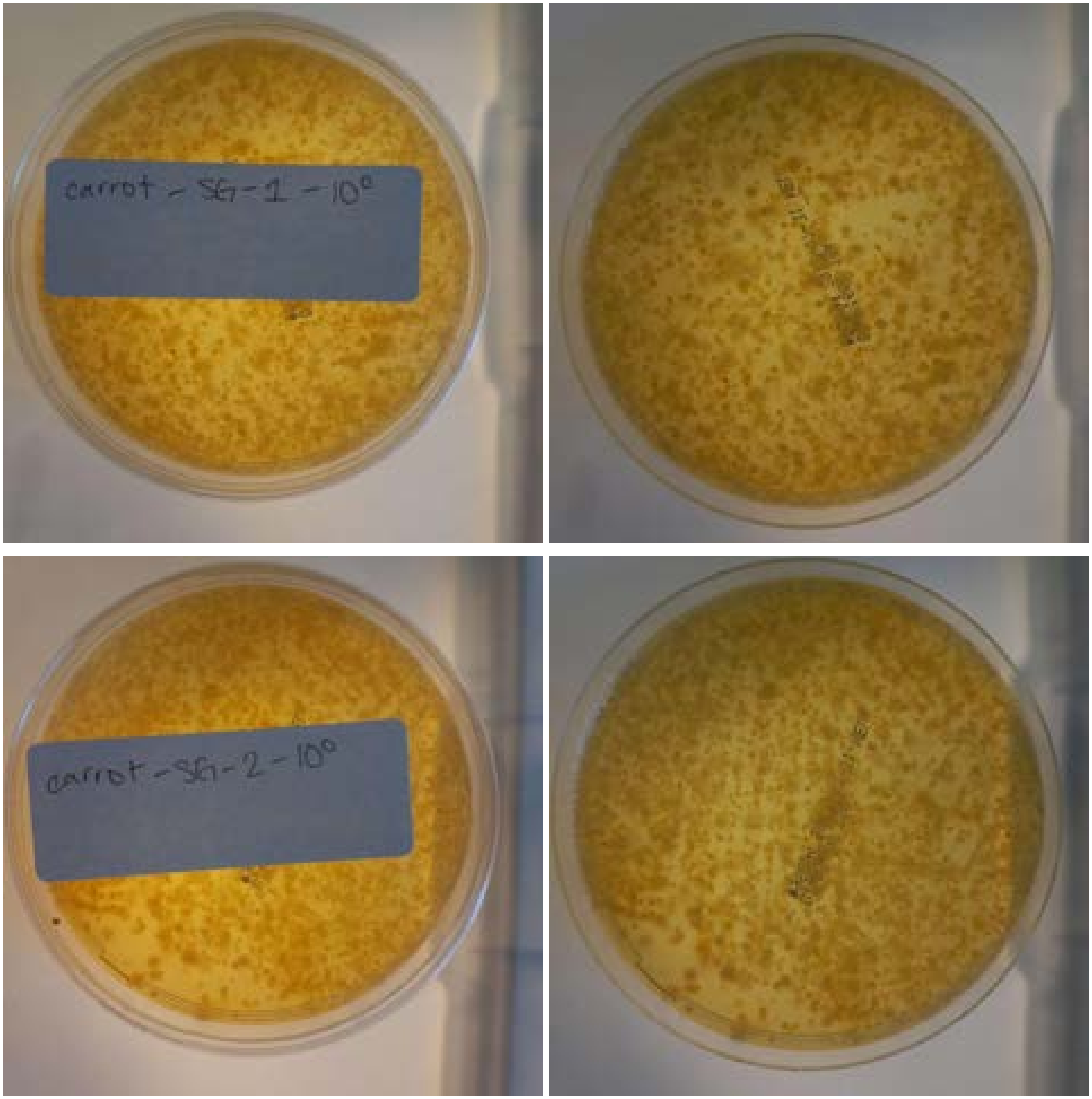
Store	Vegetable	dilution	trial	Number (CFU)	CFU/mL of original tube	**CFU/ vegetable (multiply CFU/mL by 9)**	averages	
			1	260	2.60E+05	2.34E+06		
		1	2	258	2.58E+05	2.32E+06	2.33E+06	
			1	59	5.90E+04	5.31E+05		
Store A	carrot	0.01	2	53	5.30E+04	4.77E+05	5.04E+05	1.42E+06
			1	51	5.10E+04	4.59E+05		
		1	2	76	7.60E+04	6.84E+05	5.72E+05	
			1	52	5.20E+04	4.68E+05		
	potato	0.01	2	195	1.95E+05	1.76E+06	1.11E+06	8.42E+05
			1	TNTC	TNTC	TNTC		
		1	2	TNTC	TNTC	TNTC	TNTC	
			1	494	4.94E+05	4.45E+06		
Store B	carrot	0.01	2	596	5.96E+05	5.36E+06	4.91E+06	4.91E+06
			1	56	5.60E+04	5.04E+05		
		1	2	67	6.70E+04	6.03E+05	5.54E+05	
			1	6	6.00E+03	5.40E+04		
	potato	0.01	2	7	7.00E+03	6.30E+04	5.85E+04	3.06E+05
			1	TNTC	TNTC	TNTC		
		1	2	TNTC	TNTC	TNTC	TNTC	
			1	532	5.32E+05	4.79E+06		
Store C	carrot	0.01	2	588	5.88E+05	5.29E+06	5.04E+06	5.04E+06
			1	11	1.10E+04	9.90E+04		
		1	2	14	1.40E+04	1.26E+05	1.13E+05	
			1	3	3.00E+03	2.70E+04		
	potato	0.01	2	1	1.00E+03	9.00E+03	1.80E+04	6.53E+04

In contrast, carrots exhibited a higher bacterial concentration across the studied stores, with an average of 3.79 × 10^6 colony-forming units (CFU) per carrot sample. This trend appears to align with the nature of carrots as a source for microbial growth. The respective average CFU counts for carrots from Store A, Store B, and Store C were 1.42E+06, 4.91E+06, and 5.04E+06, respectively, not including the TNTC results. In a similar study, Määttä et al. (2013) reported a mean CFU count of 5.5 log CFU/g for carrots [4]. Comparing the CFU counts of diluted carrot samples (10^{-2} cfu) with non-diluted plates revealed similar counts, suggesting a potential procedural discrepancy, possibly stemming from improper dilution techniques or contamination. Given the higher bacterial load observed in carrots, future experiments should consider employing more substantial dilution factors.

There may have also been confounding variables we may not have considered, such as the cleaning methods by the farms beforehand. We did not know how long the vegetables were in the store before restocking, so freshness was unknown. It was also unknown how misting the vegetables could have contributed to cleanliness. We hypothesized that misting may have kept the vegetables cool to prevent spoilage, but may also have caused humidity towards the bottom which would accelerate the growth of some bacteria.



Store B results, TNTC shown above, label pictured to the left with an uncovered image of the plate on the right



Store C results, TNTC shown above, label pictured to the left with an uncovered image of the plate on the right

Conclusion

Our findings reveal no observable relation between store size and bacterial concentration on the surfaces of carrots and potatoes. In future studies, ensuring proper dilution techniques will be essential to accurately capture and assess microbial concentrations, thereby enhancing the precision and reliability of the results. Confounding variables must also be accounted for if this study is conducted again. In addition, an extended investigation encompassing additional types of produce and across different size farms or suppliers could provide a more comprehensive understanding of microbial contamination patterns.

References

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