Microbial Quality of Value-added Commodities Acquired from Farmers' Markets in Central Virginia

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ABSTRACT

The popularity of local foods is showing no sign of slowing down, as evidenced by the increasing number of farmers' markets offering a wide variety of fresh food products to customers. This study aimed to survey the prevalence and characterization of foodborne pathogens on selected local food products procured from farmers' markets in Central Virginia. A total of 194 samples sold by 43 vendors at 12 registered farmers' markets in Central Virginia were obtained between March 2017 and November 2017. Bacterial isolates were tested for their susceptibility to 12 antimicrobials representing nine different categories. Pulsed-field gel electrophoresis (PFGE) profiles of the isolated *E. coli* were further explored for genomic diversity and environmental association to identify potential pathways of bacterial transmission concerning the routes of contamination. The highest aerobic mesophilic and psychrotrophic counts were observed from street corn (9.20 log CFU/g) and ground beef (9.69 CFU/g), respectively. The highest level of coliforms were found in pork sausage (2.62 log MPN/g). Detection of 24.7% *E. coli*, 17.5% *Listeria,* 1.5% *Campylobacter*, and 1.0% *Salmonella* were discovered in tested samples. Ampicillin, amoxicillin-clavulanic acid, and streptomycin showed the highest frequency of resistance among *Campylobacter* (100%) and *Salmonella* (100%) isolates while tetracycline showed the highest frequency of resistance in *E. coli* isolates (35%). Approximately 16.1% *E. coli*, 61.8% *Listeria*, 100% *Campylobacter,* and 100% *Salmonella* isolates exhibited resistance to three or more categories of antimicrobials, meeting criteria for multidrug resistance. Matching *E. coli* PFGE profiles obtained from different food products (pork chop and pork kidney) processed at the same facility manifested the potential of inter-transmission of the bacteria. This study demonstrated a potential health hazard arising from farmers' market-acquired local food products and emphasizes the importance of food safety training for food producers, farmers' market vendors, and consumers as a whole to prevent foodborne illness. Further research is needed to determine and intervene the cause(s) of the observed prevalence and to support the healthy development of food products sold at farmers' markets.

INTRODUCTION

Many consumers support local farms and their food production because they perceive that: 1) foods from local farms are fresher, healthier, and taste better than those shipped long distances from other states or countries; 2) buying local food stimulates local economic development; 3) knowing the location and/or operation where their food is produced adds to their confidence in the safety of the products they procured; and 4) buying locally can reduce carbon dioxide emissions and other environmental impacts from long-distance product distribution (Benfeldt et al. 2011). The number of farmers' markets has steadily increased over the past twenty years (USDA-AMS 2014), and a recent survey listed locally-sourced food products as the number one menu trend (Scheinberg and Cutter 2014). With 249 markets listed, VA ranks in the top 10 farmers' market states (Paitsel 2014). Farmers' markets provide an important and a popular source of food products for many American communities including many in Virginia; products processed by farmers on a relatively small scale, however, are quite different from those produced by their large scale counterparts in that they are generally unregulated and may come with their own sets of agricultural and sanitation practices procedures. These practices could increase the risk of product contamination due to on-farm handling, transportation, and/or display at the market itself. In addition, data on the food safety risks associated with small farm production are lacking (Xu et al. 2015).

OBJECTIVES

- **Evaluate microbial quality of value-added commodities acquired from farmers' markets in Central Virginia.**
- **Investigate the prevalence of multi-drug resistance (MDR) in microorganisms isolated from farmers' market-procured food products.**
- **Evaluate microbial genomic diversity and their strain relatedness associated with food products and market sources utilizing molecular analysis.**

Data Analysis: Log-transformed microbial populations obtained from duplicates of each sample were averaged and subjected to an analysis of variance and Duncan's multiple range test (SAS Institute, Cary, NC) to determine the significance of the differences (P<0.05) in mean populations of microorganisms. For PFGE band patterns, binary codes were used to generate a dendrogram of genotypic relatedness with Exter NTSYSpc software.

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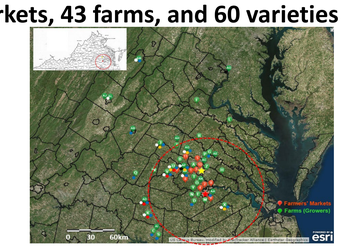
MATERIALS AND METHODS

Commodities tested: 12 farmers' markets, 43 farms, and 60 varieties

Classification	Samples	Varieties
Animal feed and treat	chicken parts, fish cookies, jerky, lamb bone, pork bone	5
Canned food	beet pickles, hot pepper jams, kimchi, mixed berry jams, relish, sauerkraut	6
Dairy products	cheese	1
Eggs	chicken egg	1
Herb and spices	basil, herb and salt blend, German chamomile, jalapeno, parsley, poultry seasoning, seasoning blend	7
Honey	cinnamon honey, raw honey	2
Juice	apple cider, mixed produce, raspberry lime	3
Meats	beef bone, beef stew, ground beef, ground lamb, ground pork, ham hock, lamb arm roast, lamb loin chops, pork chops, pork roast, seasoned pork	11
Poultry	chicken thigh, chicken whole leg	2
Sauces, salsa and dressing	apple sauce, chicken salad dressing, garden fresh salsa, habanero salsa, Mexi-Cali street corn dressing, tomato sauce	6
Sausages	basque, bratwurst, country, hot dog, Italian, Kolbassi, mortadella, Pork	8
Exotic food	beef liver, beef oxtail, pork kidney, smoked hog jaw	4
Others	bio-solids, oat bar, pollen, sunflower sprout	4



Microbial Quality Analysis

194 commodities

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Homogenize with sterile peptone water

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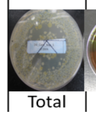
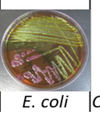
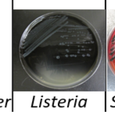
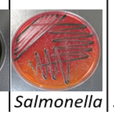
SMA	LST MPN BGBB EC-MUG	CCDA Gram staining Microscope	UVM MOX API	BPW RV, M XLD, API	BP+EYT Rabbit plasma Staining, Micro
					
Total	*E. coli*	*Campylobacter*	*Listeria*	*Salmonella*	*Staphylococcus*

Antibiotic Resistance Analysis

Antimicrobial category	Antimicrobial agent and its abbreviation	Concentration (µg/disk)	Zone diameter (mm)/ Interpretive criteria*		
			S	I	R
Penicillins	Ampicillin (AMP)	10	≥ 17	14 - 16	≤ 13
β - lactamase inhibitor combinations	Amoxicillin - clavulanic acid (AMC)	30	≥ 18	14 - 17	≤ 13
Carbapenems	Meropenem (MEM)	10	≥ 23	20 - 22	≤ 19
Aminoglycosides	Amikacin (AMK)	30	≥ 17	15 - 16	≤ 14
	Gentamicin (GEN)	10	≥ 15	13 - 14	≤ 12
	Streptomycin (STR)	10	≥ 15	12 - 14	≤ 11
	Tobramycin (TOB)	10	≥ 15	13 - 14	≤ 12
Tetracyclines	Tetracycline (TCY)	30	≥ 15	12 - 14	≤ 11
Fluoroquinolones	Ciprofloxacin (CIP)	5	≥ 21	16 - 20	≤ 15
Quinolones	Nalidixic acid (NAL)	30	≥ 19	14 - 18	≤ 13
Phenicols	Chloramphenicol (CHL)	30	≥ 18	13 - 17	≤ 12
Folate pathway inhibitors	Trimethoprim - sulfamethoxazole (SXT)	25	≥ 16	11 - 15	≤ 10

Pulsed-Field Gel Electrophoresis

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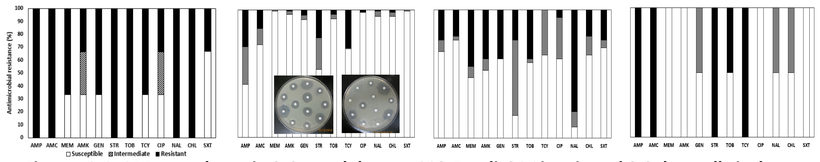
RESULTS AND DISCUSSION

Table 1. The level of total aerobic mesophile counts.

Classification	No. of samples	% of samples in the indicated interval				Range	Mean
		<3	3-5	5-7	>7		
Animal feed and treat	16	18.7	50	12.5	18.7	2.7-9.5	5.0±2.1 bc
Canned food	16	0	87.5	12.5	0	3-6.5	3.5±1.1 c
Dairy products	8	0.0	0.0	37.5	62.5	6.2-7.7	6.9±0.6 a
Eggs	10	10	70	20	0.0	2.9-6.3	4.0±1.1 c
Herb and spices	24	4.1	41.6	37.5	16.6	2.8-7.9	5.1±1.6 abc
Honey	4	25	75	0.0	0.0	2.9-3.7	3.4±0.3 c
Juice	6	33.3	33.3	33.3	0.0	2.9-5.6	4.0±1.1 c
Meats	34	2.9	20.5	29.4	47.0	2.5-9.3	6.3±1.6 ab
Poultry	6	0.0	66.6	33.3	0.0	3.4-7	4.8±1.3bc
Sauces, salsa and dressing	18	22.2	55.5	0.0	22.2	2.5-9.2	4.2±2.5 c
Sausages	34	5.8	35.2	14.5	44.1	2.5-9.1	6.2±2.0 ab
Exotic food	8	0.0	25	37.5	37.5	5-7.6	6.5±1.0 ab
Others	10	40	20	0.0	40	2.4-8.7	4.8±2.9 bc

Table 2. Prevalence of pathogens.

Classification	No. of samples	% of samples with pathogens			
		Campylobacter	*E. coli*	*Listeria*	*Salmonella*
Animal feed and treat	16	6.3	25.0	6.3	0.0
Canned food	16	0.0	0.0	0.0	0.0
Dairy products	8	0.0	0.0	0.0	0.0
Eggs	10	0.0	10.0	0.0	10.0
Herb and spices	24	0.0	4.1	0.0	0.0
Honey	4	0.0	0.0	0.0	0.0
Juice	6	0.0	0.0	0.0	0.0
Meats	34	0.0	47.0	29.4	2.9
Poultry	6	0.0	66.6	0.0	0.0
Sauces, salsa and dressing	18	0.0	0.0	0.0	0.0
Sausages	34	0.0	50.0	47.0	0.0
Exotic food	8	0.0	50.0	50.0	0.0
Others	10	20.0	0.0	10.0	0.0



Figures 1-4. ABR prevalence in 3 *Campylobacter*, 118 *E. coli*, 34 *Listeria* and 2 *Salmonella* isolates.

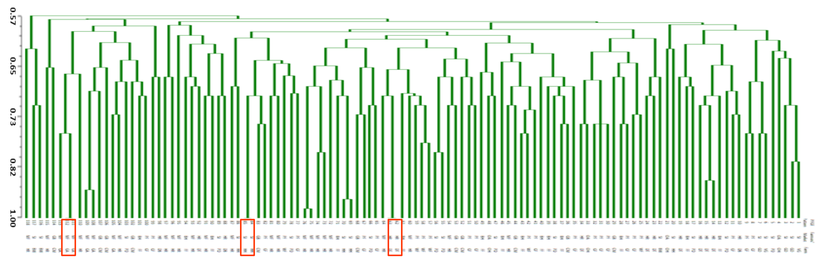


Figure 5. Dendrogram of *E. coli* PFGE profiles.

- **Approximately 24.7% *E. coli*, 1.5% *Campylobacter*, 17.5% *Listeria* and 1.0% *Salmonella* of total samples were detected.**
- **Approximately 16.1% *E. coli*, 61.8% *Listeria*, 100% *Campylobacter* and 100% *Salmonella* isolates exhibited resistance to three or more categories of antimicrobials (Multi-Drug Resistance).**
- **Matching *E. coli* PFGE profiles obtained from different food products (pork chop and pork kidney) processed at the same facility manifested the potential of inter-transmission of the bacteria.**

CONCLUSIONS

- **Findings in this clearly demonstrates a potential health hazard arising from farmers' market-acquired food products and emphasizes the importance of good agricultural and handling practices to prevent foodborne illness.**
- **Continued research is needed to determine the cause(s) of the observed differences in microbial counts and prevalence and to support the healthy development of food products sold at farmers' markets.**