

# Influence of Market Setting and Time of Purchase on *Salmonella* and *Listeria* Prevalence in Beef and Pork in Vietnam

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**Abstract - The objective of this study was to determine the influence of market type and sampling time on *Salmonella* and *Listeria* prevalence for 360 beef (n = 180) and pork (n = 180) samples collected in 6 supermarkets (SM), 6 indoor markets (IM), and 6 open markets (OM) at opening (T0) and 4 h after the opening (T4) in Vietnam. *Salmonella* prevalence in beef was more than 50% and was influenced by market type and sampling time ( $P = 0.082$  and  $0.019$ , respectively). *Salmonella* presence in pork (42.9%) was influenced only by market type ( $P = 0.049$ ). *Listeria* spp. prevalence was greater than 90% and 64% in beef and pork, respectively, and was influenced by neither market type nor sampling time.**

**Keywords – Beef, Food safety, *Listeria*, Pork, *Salmonella*, Vietnam.**

## I. INTRODUCTION

Meat is among the most nutritious foods in developing countries [1, 2] since protein is usually the most limited nutrient. Meat consumption increases as standard of living improves [3]. Therefore, meat safety is increasingly important in developing countries. However, there is minimal published information on the safety of meats in various markets in Vietnam. As a highly perishable food, beef is a suitable medium for the growth of various microorganisms and a reservoir through which foodborne illnesses may spread [4]. Moreover, pork is the most consumed meat in the world [5], but can also be a source of foodborne illness. Traditional open markets in developing countries pose serious safety risks to consumers because of the lack of refrigeration and exposure of meats to the open environment [6]. Supermarkets store and display meat products in refrigerated display cases but still face safety challenges because they primarily purchase beef and pork from similar slaughter and packaging sources [7]. Therefore, the objective of this study was to investigate *Salmonella* and *Listeria* prevalence in supermarkets (SM), indoor markets (IM), and open markets (OM) at two sampling times, opening (T0) and 4 h after (T4), in Ho Chi Minh City (HCMC), Da Nang (DN), and Ha Noi (HN) in Vietnam.

## II. MATERIALS AND METHODS

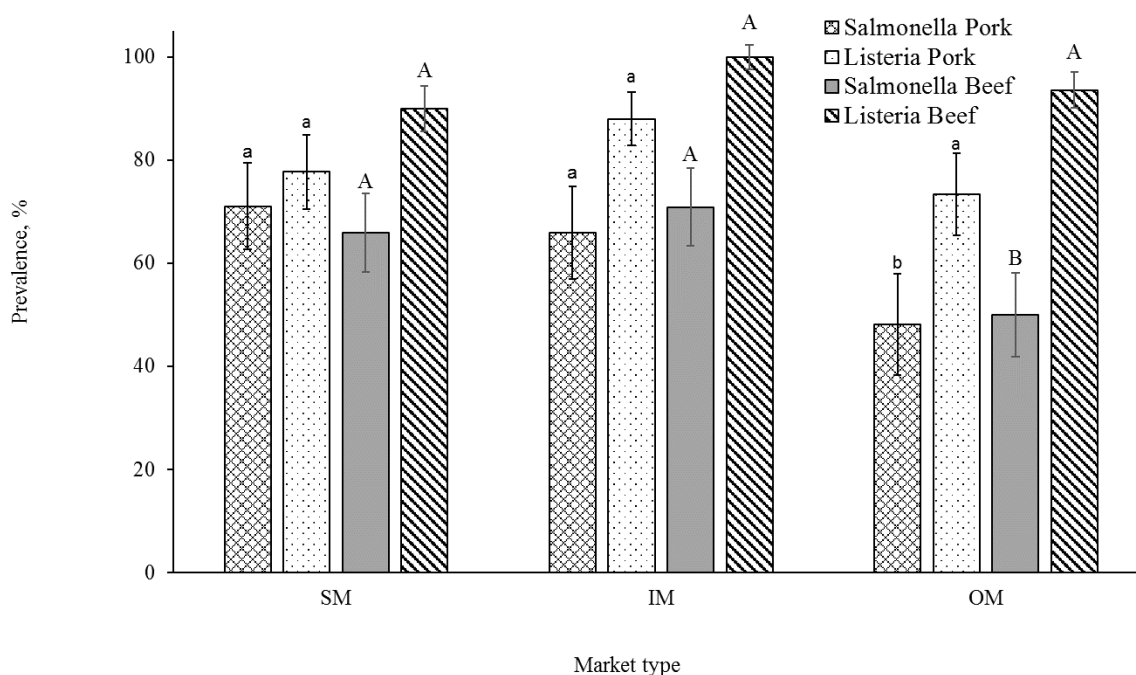
*Salmonella* and *Listeria* were analyzed as described by McCain et al. (2015). Briefly, in two sterile Whirl-Pak<sup>®</sup> bags, 2.5 mL of Buffered Peptone Water rinsate and 22.5 mL of *Salmonella* Enrichment Broth and Demi-Fraser *Listeria* Enrichment Broth were individually combined and incubated at 45°C and 30°C for 24 h, respectively. After incubation, 1 mL of solution was combined with 10 mL of Rappaport-Vassiliadis R10 Broth and incubated at 41.5°C for 24 h. A 10- $\mu$ L streak of the incubated RVR10 solution was streaked onto 3M<sup>™</sup> Petrifilm<sup>™</sup> of the *Salmonella* Express System. The Petrifilm<sup>™</sup> was incubated at 41.5°C for 24 h. Presumptive positive *Salmonella* spp. colonies were identified by a red color with yellow halo. Similarly, 0.1 ml of incubated *Listeria* Enrichment Broth was spread onto an ALOA<sup>®</sup> agar petri dish and incubated at 37°C for 24 h. Presumptive positive *Listeria* spp. colonies were identified by a blue to green color with or without halo. Prevalence was analyzed as binomial data in a generalized linear mixed model by the GLIMMIX procedure of SAS v9.4 at 0.10 level of significance.

## III. RESULTS AND DISCUSSION

**Beef:** The average presence of *Salmonella* in SM, IM, and OM was 66.0, 71.0, and 50.0%, respectively (Figure 1). Across two sampling times, SM and IM were similar in prevalence of *Salmonella*, and both markets had greater incidence than OM ( $P = 0.098$  and  $0.037$ , respectively). Across three market types, the *Salmonella* prevalence in beef was greater at T4 than at T0 (71.7 and 52.6%, respectively;  $P = 0.019$ ). Market type and sampling time did not affect *Listeria* prevalence in beef across all three regions of Vietnam ( $P > 0.773$ ). The average prevalence of *Listeria* was determined at 90.0, 100.0, and 93.6% for SM, IM, and OM, respectively and at 92.5 and 99.9% for T0 and T4, respectively.

*Pork: Salmonella* prevalence was 71.1, 65.9, and 48.1% in SM, IM, and OM (Figure 1). Market type influenced *Salmonella* prevalence in pork ( $P = 0.049$ ) with OM having less incidence than both IM and SM ( $P = 0.069$  and  $P = 0.021$ ), whereas IM and SM *Salmonella* prevalence was similar ( $P = 0.559$ ). There was no effect of sampling time on *Salmonella* incidence ( $P = 0.700$ ). Market type did not affect *Listeria* prevalence in pork across all three regions of Vietnam ( $P = 0.162$ ) with 77.7, 87.9, and 73.4% in SM, IM, and OM, respectively. *Listeria* prevalence was not affected by sampling time ( $P = 0.817$ , Figure 5), with averages of 79.7 and 81.2% in T0 and T4.

Figure 1. *Salmonella* and *Listeria* prevalence of beef and pork purchased at two time points (opening -T0 and 4 h after opening -T4), across three market types (supermarket (SM), indoor market (IM), and open market (OM)), and three regions of Vietnam (Ho Chi Minh City, Da Nang, and Ha Noi). Within a pathogen category, means without common letters differ, (Pork  $P_{\text{market type}} = 0.049$  *Salmonella* and 0.162 *Listeria* and Beef  $P_{\text{market type}} = 0.082$  *Salmonella* and 0.773 *Listeria*).



#### IV. CONCLUSION

Beef and pork samples had high incidence rates of *Salmonella* and *Listeria*. The incidence of *Salmonella* and *Listeria* in various market types found in Vietnam in the current study was greater than what was reported in China, Malaysia, Japan, and South Korea. Refrigeration, cleanliness, water usage, and good hygienic conditions at harvest and in market can improve the status of microbiological safety and quality of meat products in Vietnam. Much research is needed to establish a baseline for contamination at critical control points during beef and pork processing in Vietnam's meat markets with additional investigation into harvest practices. These data justify an enhanced enforcement of food safety regulations and a creation of education programs for both consumers and vendors in Vietnam's meat markets.

#### ACKNOWLEDGEMENTS

This study was funded in part by the U.S. Borlaug Fellows in Global Food Security Program Graduate Research Grant (Grant #00000861). Work in Dr. Janet R. Donaldson's laboratory was supported by NIH #P20GM103646. Microbiological training was provided by the International Center for Food Industry Excellence at Texas Tech University.

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