Impact of Rearing Conditions on the Microbiological Quality of Retail Poultry Meat

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Dedication

I would like to dedicate this thesis to my late Uncle Lee A. Hardy. He was a kind, loving, caring person who would do anything for anybody. I hope I make you proud and I'm thankful for the love and guidance I received from you over the years.

I love you and miss you.

Rest in Peace

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"*A wide door has been opened to me and with it are many adversaries. –*

I Corinthians 16:9"

ABSTRACT

Poultry and poultry products are a leading source of foodborne pathogens and illnesses. The rearing conditions of poultry can be an influential factor on the presence of foodborne pathogens including *Campylobacter* and *Salmonella* because some types of rearing practices have increased risks in terms of biosecurity. However, there is a gap in knowledge of food safety in raw chicken products and no studies have reported the microbiological quality of turkeys produced under different rearing environments. Thus, the aim of this study was to compare conventionally and organically-reared whole chicken and turkey carcasses purchased from three retail outlets in Knoxville, TN. A total of 50 conventionally-raised and 50 organically-reared chicken carcasses were evaluated. A total of 25 conventionally-raised and 25 organically-reared turkey carcasses were evaluated. The Food and Drug Administration Bacteriological Analytical Manual protocol for rinsing whole poultry carcasses was used for the isolation of *Salmonella*, *Staphylococcus*, and *Campylobacter* and to determine total aerobic bacteria counts. *Salmonella* was isolated only from organic chickens and turkeys. Organic turkey had the highest prevalence of *Staphylococcus* and *Campylobacter* but differences were not statistically significant. From this data, it appears that the rearing conditions of the poultry carcasses evaluated in this study did not affect the microbiological quality however the microbiological was dependent on the producer.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

INTRODUCTION

"Broilers" are chickens that are produced for meat while "Layers" are chickens produced for eggs (Martinez, 1999). In the United States, the broiler industry was the last part of the poultry industry to be developed, but has surpassed beef as the leader of meat production. The broiler industry began to grow as one of the most integrated agricultural industries in the United States after World War II (Martinez et al., 1999). Before World War II most of the chickens that were cooked for meat were hens that outlived their fertility or young roosters (Martinez et al., 1999). During World War II consumption of chicken increased because. unlike red meat, poultry was not rationed. Despite the heavy loss of poultry to diseases and poor feed quality, between 1940 and 1945, broiler production nearly tripled (Martinez et al., 1999).

As the growth of the broiler industry grew, the demands for feed increased and the technology for production improved. Large feed companies developed production contracts with growers because they realized the potential for growth in the poultry industry (Martinez et al., 1999). Furthermore, during this time, the cotton industry was on a steady decline, which eventually encouraged expansion of the broiler industry in the south (Martinez 1999). Alabama, Mississippi,

Georgia, North Carolina and Arkansas produced 27 percent of the United States broilers in the 1950s. Within 15 years they became the top five states for broiler production by producing more than 60 percent of the broilers in the nation (Martinez et al., 1999).

In 1957 the Poultry Products Inspection Act (PPIA) was passed which required all broilers traded across state lines to be inspected by the USDA by 1959. Before the act, the USDA offered inspections of broilers voluntarily. The purpose of the PPIA was to protect against poor quality health practices because of a rise in deaths from bacterial disease in people that were traced to contaminated poultry meat. Also the PPIA was established to instill confidence in consumers to purchase poultry meat. Following implementation of the act, processors built new plants to meet the inspection requirements and the inspection of broilers increased from 25 percent to 75 percent in 1 year (Martinez 1999).

REARING METHODS

There is no current standard definition describing conventional methods of farming and production for poultry. According to the United States Department of Agriculture (USDA), conventional farming systems vary from farm to farm and from country to country but share many characteristics in common including rapid technological innovation, large capital investments in order to apply production and management technology on a large-scale. When dealing with livestock or food-producing animals, most production involves confined and concentrated

systems (Gold, 2007). Over the years other methods of rearing chickens have emerged. During the last decade, organic animal production became increasingly important (Berg, 2002). USDA eventually established, the National Organic Program (NOP). It is a marketing service within the USDA that focuses on guidelines and standards. Guidelines have been set by the USDA Food Safety and Inspection Service (FSIS) for organic poultry production. Organic poultry must utilize organic feed, have access to outdoors, not be administered antibiotics, and be produced on premises that the USDA certifies as organic (Huask et al., 2008).

In organic food production most synthetic materials are not permitted but natural materials that are listed by the NOP are permitted. With antibiotics not being allowed in organic poultry production, proactive health supervision is very important (Fanatico et al., 2009). Antibiotic growth promoters may be replaced with probiotics and prebiotics in organic poultry production. Prebiotics are indigestible substances that only gastrointestinal bacteria are able to ferment and utilize as energy substrates which promotes the growth of beneficial bacteria in the gastrointestinal tract (Lilly et al., 2011). Probiotics are beneficial bacteria typically found in the intestinal tract that are fed directly to the birds.

Organic birds must have access to outdoors and have room to be able to exercise and carry out natural behaviors (Fanatico et al., 2009). Cages are not permitted with the rearing of organic birds. However, it is understood that weather plays a role and thus, shelter of some type should be provided. Shelter

for birds must contain clean bedding, comfortable temperature, and proper ventilation. In the United States there is no limit to the number of birds that can be raised in a flock (Fanatico, Owens, & Emmert, 2009). Similar to the conventional industry, in the United States, most organic poultry are raised in large scale conditions (Fanatico, et al., 2009).

Since 2005, the organic meat category has been the fastest growing division of organic food production with organic broilers being in the lead (Fanatico, et al., 2009). It was reported in 2005 that Nebraska, Pennsylvania, and California were the highest organic poultry producing states. Organic poultry has become more available in stores and supermarkets nationwide (Husak, Sebranek, & Bregendahl, 2008). Organic producers are thought to focus more on the welfare, health, and product quality where as conventional methods focus on maximizing production while minimizing cost (Fanatico, et al., 2009) .

FOODBORNE PATHOGENS

A subject that continues to be a global health concern is food safety (Velusamy et al., 2010). Foodborne illnesses are defined by the World Health Organization (WHO) as diseases which are toxic or infectious in nature. The latter illnesses are caused by an agent that enters the body through the ingestion of food (Velusamy et al., 2010).There is an underestimation of foodborne diseases incidence because they may not be reported and many outbreaks of food poisoning cases are misdiagnosed (Mor-Mur et al., 2009). 37.2 million e

pisodes of foodborne illness are estimated to occur annually in the United

States (Scallan et al., 2011). 31 known pathogens in the United States causes illnesses and about 1,351 of the cases result in death (Scallan et al., 2011). Mishandling foods in manufacturing and during preparation by consumers such as improper cooling, heating inadequately, and poor hygiene are some risk factors in acquiring foodborne disease (Mor-Mur & Yuste, 2009).

Over the years, publications on food safety have increasingly become available to consumers. At the manufacturing level Hazard Analysis and Control Points (HAACP) principles along with Good Manufacturing practices (GMP) have been developed in the United States to reduce the risk of contamination in food production processes (Mor-Mur & Yuste, 2009). HACCP consists of guidelines that focus on the wholesomeness and safety of food products (Osiriphun et al., 2011). These guidelines identify methods to reduce, target, and control potential hazards to food and to prevent pathogens in poultry and other meat (Pope et al., 2011

The USDA Food Safety and Inspection Service has food inspection responsibility for poultry and other meat products. GMPs are general guidelines and regulations for food manufacturing but the agency does not enforce it for poultry. GMPs focus on controlling the risk of contamination of food items. Some of the guidelines focus on steps like personal hygiene, which deals with washing hands and overall worker cleanliness. Proper use of GMPs can minimize the risk of cross-contamination.

Raw products or undercooked contaminated red meats and poultry

are important vectors for transmitting foodborne pathogens (Zhao et al., 2001). The majority of foodborne outbreaks are caused by *Salmonella, Listeria monocytogenes, Escherichia coli* O157:H7, and *Campylobacter* (Velusamy, Arshak, Korostynska, Oliwa, & Adley, 2010). *Salmonella* and *Campylobacter* are prevalent in poultry and are also considered two of the most prevalent foodborne pathogens worldwide (Heur et al., 2001).

Epidemiological studies show that poultry eggs and meat are two of the most important sources for consumer ingestion and contact of pathogens (Luber, 2009). Cross-contamination and undercooking are considered the most common routes for humans exposure to the pathogens that may contaminate poultry and other meat. Water, feed, and other animals on the farm are potential means of contamination for pre-harvest poultry (Doyle et al., 2006).

To determine the safety and potential shelflife of poultry, it is necessary to determine the presence of both spoilage and pathogenic bacteria (Pal 2011). Some methods used to analyze or detect bacteria in foods are immunology-based methods, polymerase chain reaction (PCR) methods, and methods that use biosensors (Velusamy, et al., 2010). However, traditional culturing is often regarded as the gold standard for detection and identification of viable pathogens (Pal 2011; (Velusamy, et al., 2010). However, one of the major drawbacks of conventional culturing method is the time required for results which ranges from 2 to 5 days (Pal 2011).

CAMPYLOBACTER

In the United States and worldwide *Campylobacter* remains the leading cause of foodborne bacterial illness (Lestari et al., 2009). It is estimated that *Campylobacter* is responsible for over 840,000 cases of foodborne illness in the United States annually (Scallan et at., 2011). The types of outbreak cases and sporadic cases for *Campylobacter* infections differ. Untreated raw milk is the main source of outbreaks while consumption of undercooked poultry meat or exposure to food that has been contaminated from raw poultry typically causes sporadic cases of Campylobacteriosis (Heuer, Pedersen, Andersen, & Madsen, 2001).

The two *Campylobacter* species that are primarily responsible for the majority of human infections are *Campylobacter jejuni* and *coli* (Lestari et al., 2009). More than 90% of the cases of Campylobacteriosis are caused by *C. jejuni* although, there has been an increase in the number *C. coli* infections (Allen et al., 2011). In many developed countries Campylobacteriosis is considered a primary public health problem (Heuer, et al., 2001).

Most cases of Campylobacteriosis from *Campylobacter* infections are self-limiting (Lestari et al., 2009). However, people with immune deficiency diseases, infants and elderly people have a higher risk of acquiring a severe case of Campylobacteriosis (Lestari et al., 2009). The infectious dose of *Campylobacter* is low; less than 500 cells can cause disease (Black et al. 1998). Diarrhea, fever, and vomiting are the major symptoms reported by the Centers

for Disease Control and Prevention (CDC). Bloody stool along with headaches, nausea, and abdominal pains are other symptoms that may be present. The incubation period is 2 to 5 days which makes trace back efforts difficult *Campylobacter* is also known for causing reactive arthritis and Guillain-Barré syndrome (Blaser, 1997). According to the CDC, there are studies demonstrating 40% of patients with Guillain-Barré syndrome had preceding *Campylobacter* infection.

Campylobacter species are obligate microaerophiles, which means it requires reduced oxygen level for growth. *Campylobacter* optimal temperature for growth is 42°C (Mor-Mur & Yuste, 2009). Culturing the organism in the past was difficult because of the unusual growth requirements (Mor-Mur & Yuste, 2009). *Campylobacter* is readily killed by heat but it is capable of surviving freezing and refrigeration which are common ways to preserve food. *Campylobacter* can colonize the gastrointestinal tracts of wild and domestic animals, especially poultry produced for human consumption (Zhao et al., 2001). Even when high numbers of *Campylobacter jejuni* are carried in the intestinal tract of poultry, there are little to no symptoms or signs of illness detectable in birds (Mor-Mur et al., 2009).

SALMONELLA

A second foodborne pathogen associated with contaminated poultry meat is *Salmonella* (Heyndrlckx et al., 2002). A priority of USDA FSIS is to reduce the amount of *Salmonella* species in poultry products as well as other meats,

especially in broilers, because poultry products are a leading source of *Salmonella* infections (USDA FSIS 2011). *Salmonella* is a Gram-negative non-spore forming organism with two species causing illness in humans, *S. enterica* and *S. bongori.* There are over 41,000 laboratory confirmed cases of foodborne illnesses caused by *Salmonella* annually in the United States (Scallan et al., 2011). Common symptoms of Salmonellosis include abdominal cramps, fever, and diarrhea and they occur 12 to 72 hours after consumption of contaminated food (Finstad, O'Bryan, Marcy, Crandall, & Ricke, 2012).

With *Salmonella*, the infectious dose varies but is typically high, between 10^4-10^9 (Rumyantse et al., 2004). Like *Campylobacter*, the dose needed to cause infection depends on the patients age and health along with the food that was consumed (Finstad, et al., 2012). Children 4 years of age and under along with adults 50 years of age and older made up most of the confirmed cases of Salmonellosis in 2009 (Finstad, et al., 2012). It has been estimated that 90% of cases of salmonellosis are acquired from food. Improper food handling and cross contamination cause the majority of foodborne salmonellosis infections regardless whether the food was consumed inside or outside the home (Finstad, et al., 2012).

According to the CDC, *Salmonella* Typhimurium and *Salmonella* Enteritidis are the two most frequently reported serotypes in the United States (Carrasco et al., 2012). In the late 90s *Salmonella* Typhimurium caused most of cases of salmonellosis. The consumption of eggs and poultry are commonly

associated with *Salmonella* Enteriditis while S. Typhimurium is usually linked to poultry meat as well as other food-producing animals (Carrasco, Morales-Rueda, & García-Gimeno, 2012). For broilers, feed is considered to be a main source for contamination by *Salmonella* (Petkar et al., 2011). It has been documented that the sanitary conditions of storage can impact the prevalence of *Salmonella* in feed (Petkar et al., 2011). To control *Salmonella* in feed, methods such as irradiation, heating, or addition of antimicrobial chemicals have been used (Petkar et al., 2011). *Salmonella* is able to multiply in the gastrointestinal tract of the poultry after contaminated feed is consumed. The bird can then potentially shed *Salmonella* in the feces spreading the bacteria via vertical transmission (Petkar et al., 2011). Bacteria can also continue to spread during processing by cross-contamination of the carcasses through fecal contamination.

There are certain stages during processing of poultry that are recognized as pathways for cross-contamination including, chilling of carcasses, scalding, evisceration and plucking (Carrasco, et al., 2012). Cross-contamination of *Salmonella* can also occur at retail. *Salmonella* can survive on surfaces that contaminated food comes in contact with for significant periods, which increases the risk of cross-contamination (Carrasco, et al., 2012). Mishandling of food in households can play an important role in cross-contamination of *Salmonella*. It was reported that 25% of outbreaks of *Salmonella* were caused by handling food inappropriately (Carrasco, et al., 2012).

STAPHYLOCOCCUS AUREUS

As a foodborne pathogen, *Staphylococcus aureus* causes an intoxication by producing a heat-stable toxin in foods in which it has grown to high levels (typically > 5 log CFU/g or ml). As a medically important pathogen, *Staphylococcus aureus* can cause serious diseases, such as septicemia and pneumonia, to something as mild as a slight skin infection (Normanno et al., 2007). In the United States and Europe, Staphylococcal foodborne intoxications have been reported as one of the most common foodborne diseases (Rode et al., 2007).

Staphylococcal food poisoning (SFP) is a mild intoxication caused by ingesting food that contains staphylococcal enterotoxin. Staphylococcal food poisoning (SFP) is responsible for a third of the foodborne diseases worldwide (Normanno, et al., 2007). One of the main causes of SFP is temperature abuse of food (Rode, Langsrud, Holck, & Møretrø, 2007). After ingestion of food that is contains sufficient enterotoxin, SFP symptoms will appear within a few hours (Normanno, et al., 2007). According to the CDC (CDC 2012), SFP symptoms range from nausea, diarrhea, cramping to more severe symptoms including dehydration and fluctuation of blood pressure. SFP has been estimated to cause at least two deaths yearly in the United States (Normanno, et al., 2007). Even though *Staphylococcal* food poisoning runs a mild course, the United States spends approximately 3.1 billion dollars a year due to SFP (Normanno, et al., 2007)

It is known to be a very adaptive organism with the capabilities to survive in different environments (Rode et al., 2007). Without causing harm to the host, some *Staphylococcus spp.* are present in the nasal passages and skin of animals and humans (Rode, Langsrud et al. 2007).

Staphylococcus aureus may cause infections in poultry such as gangrenous dermatitis, septic arthritis, and subdermal abscesses which is also called bumble foot (Lowder et al., 2009). *Staphylococcus aureus* has also been associated with the lameness of poultry (Lowder, et al., 2009).Surveys have found that *Staphylococcus aureus* is among the most common microorganism that has been isolated from different surfaces in the food industry (Rode, et al., 2007).

Poultry and meat products are tested for *Staphylococcus aureus* to assess microbiological safety, storage quality, and sanitation conditions during processing (Capita et al., 2002). Carcass contamination may be a risk when it comes to agriculturally important animals because the microorganism can be present on the skin of the animal (Hanning et al., 2012). Poultry can be considered to be a higher risk for *Staphylococcus* contamination over swine and cattle because the skin of poultry is left intact on most cuts, while the skin is removed from swine and cattle (Hanning, et al., 2012).

MICROBIOLOGICAL QUALITY OF RAW POULTRY

A survey was done to determine what motivated consumers to purchase organic chickens (Van Loo et al., 2010). Consumers considered organic chickens to be safer and have better quality along and with no genetic modifications (Van Loo et al., 2010). Higher nutritional value and increased animal welfare were other influential factors (Van Loo et al., 2010). Furthermore many consumers feel that organic poultry is safer in terms of food safety compared to the chickens that are reared conventionally (Bailey & Cosby, 2005). However, a data gap exists concerning the microbiological quality of organic poultry products. A summary of the available literature on organic poultry with respect to microbiological quality follows.

Pre-harvest

The objective of one study was to compare the level of contamination by *Campylobacter* of turkeys and broilers on 10 conventional and 5 organic farms in Ohio(Luangtongkum et al., 2006). Contamination was measured by by culturing cloacal swabs obtained from live birds. Conventionally- and organically-raised turkeys had a *Campylobacter* prevalence of 83% and 87%, respectively. The conventionally- and organically-raised broilers were 66% and 89% positive for *Campylobacter,* respectively. In Northern Spain, sixty flocks of free-range chickens were analyzed for *Listeria, Salmonella, E. coli* and *Campylobacter* (Esteban et al., 2008). In this study *Campylobacter* was the most prevalent pathogen of the four, and was isolated from 70.6% of the farms (Esteban et al.,

2008). *Salmonella* was only isolated from 2.9% of the farms. The data from this study supported the idea that free-range rearing may have a positive effect on reducing *Salmonella* but not reducing the prevalence of the other three pathogens (Esteban et al., 2008). Conversely, a comparison survey conducted on the infection and health status of organic and conventional broilers chickens in Belgium reported no significance difference in the prevalence of *Salmonella* between conventional and organic broilers (Van Overbeke et al., 2006). Rodenburg et al., (2004) surveyed 13 organic and 10 conventional broiler farms and found that there was an increase of *Salmonella* on both farms compared to the previous years of sampling. The researchers concluded that *Campylobacter* infection was the main risk on these organic farms partly due to an increased amount of access to the outdoors along with an open drinking water system (Rodenburg et al., 2004). In Quebec, Canada the risk factors and prevalence of *Salmonella* in broiler chickens and turkey flocks was studied and it appeared to be correlated with human contact (Arsenault et al., 2007). The researchers reported a reduction in *Salmonella* positive chicken flocks that were kept in locked houses and turkey flocks that had the fewest handlers.

Post-harvest

Cui et al. (2005) reported 61% of organic chickens sampled at retail were positive for *Salmonella* while 44% of conventionally-reared samples tested were positive. However, in the same study, little difference in the prevalence of *Campylobacter* was found as 76% and 74% of organic and conventional

chickens tested positive for *Campylobacter,* respectively (Cui et al., 2005). Lestari et al., (2009) sampled 53 organic and 141 conventional whole chicken carcasses from 27 retail stores in Louisiana and reported that the prevalence of *Campylobacter* on the carcasses was the same (43%) for both types of reared birds. (Heuer, et al., 2001) sampled 79 conventional and 22 organic broilers at slaughter by swabbing cloacas. *Campylobacter* was isolated from all of the organic broiler flocks while 36.7% of conventionally-raised flocks tested positive (Heuer, et al., 2001).

A few studies have been conducted on the prevalence of *Staphylococcus* prevalence in poultry. In northwest Arkansas, a total of 222 carcasses were purchased from grocery stores. In this study all of the carcasses were positive for *Staphylococcus,* but only 25 poultry carcasses were contaminated with *Staphylococcus aureus* (Hanning, et al., 2012). In Pretoria, South Africa, 43 whole broilers were purchased from supermarkets (Vorster et al., 1994). *Staphylococcus aureus was* isolated from 39.5 % of the broilers sampled. In addition, 79.1% of the carcasses were also positive for *Escherichia* coli (Vorster, Greebe, Nortj, & L., 1994). A study was conducted in China to determine the prevalence of *Staphylococcus aureus* in whole raw chickens (Wang et al., 2013). From six provinces and two cities, 1152 whole chicken samples were collected from small supermarkets, farmers markets, and large supermarkets. Of the 1152 broilers collected, 279 or 24.2% were positive for *Staphylococcus aureus* (Wang, et al., 2013). This study concluded that the rates of *Staphylococcus aureus* on

the broilers were dependent on the province from which the chicken was obtained.

CONCLUSION

The fact that foodborne pathogens have been found on poultry that were raised differently indicates that no system should be considered risk-free. There have been many studies on the prevalence of foodborne pathogens in conventional broiler systems but there is still a need for microbiological information with the nonconventional methods. The prevalence of foodborne pathogens in the different production systems vary and may be dependent on factors including sanitation procedures, quality of feed, and packaging methods. However, at the pre-harvest level, it is well documented that proper biosecurity can improve the health and overall quality of poultry. Because proper biosecurity is more of a challenge in an organic or free-range system, the microbiological quality of the final product may be impacted. The literature available is somewhat conflicting and more research concerning this topic is needed in order to draw a firm conclusion.

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CHAPTER II

IMPACT OF REARING CONDITIONS ON THE MICROBIOLOGICAL QUALITY OF RETAIL POULTRY MEAT

ABSTRACT

Poultry and poultry products are a leading source of foodborne bacterial pathogens. Rearing conditions of poultry can be an influential factor on the presence of foodborne pathogens because some types of rearing practices have increased risks in terms of biosecurity. However, there is a gap in knowledge of food safety in raw chicken products from alternate rearing systems and no studies have reported the microbiological quality of turkeys produced under different rearing environments. Thus, the aim of this study was to compare the microbiological quality of conventionally- and organically-reared whole chicken and turkey carcasses purchased from three retail outlets in Knoxville, Tennessee. A total of 50 conventionally and 50 pasture reared chicken carcasses as well as 25 conventionally-raised and 25 organically-reared turkey carcasses were evaluated. *Salmonella* was isolated only from organic chickens and turkeys. Statistically significant differences in counts of *Campylobacter*, *Staphylococcus spp*. and aerobic bacteria were found between brands of poultry, but not between different rearing types. From these data, it appears the microbiological quality of the raw retail product was not dependent on rearing conditions and thus it cannot be assumed that organic raw poultry is safer than conventionally-raised poultry in terms of food safety.

INTRODUCTION

Foodborne illnesses are estimated to cause about 37.2 million cases annually in the United States (Scallen et al. 2001). However, it is difficult to determine the true number of foodborne illnesses that occur because many people that become ill may not to seek medical attention. Poultry and poultry products are leading sources of *Campylobacter* and *Salmonella* and these two pathogens are the leading causes of foodborne illness throughout the world (Heuer et al., 2001). Because poultry and poultry products are important sources of consumer exposure to foodborne pathogens, the USDA FSIS is focused on reducing foodborne illness associated with these products (Luangtongkum, et al., 2006).

There are many factors that may influence a consumer to purchase certain types of food products. Cost, wholesomeness, quality, nutrition value, and information on the label are some of the factors that influence consumers (Huask et al., 2008). Surveys indicate that the method of production (organic versus conventional) is also an important aspect of food preference (Fanatico et al., 2009). For poultry specifically, some consumers prefer organic over conventionally-raised poultry due to the belief that organic poultry meat is better quality, has better taste and improved nutritional content (Van Loo et al., 2010). This belief has partially driven the recent and dramatic increase in the sale of organically produced broilers. In 2005, the sales of organic poultry increased by

55.4% despite the fact that price premiums for organic broilers increased from 169% in 2004 to 262% in 2006 (Oberholtzer et al., 2006).

Food safety concerns for organic and free-range poultry products have been raised because these systems are more challenging than conventional systems in terms of biosecurity. In these production environments, there is an increased risk of poultry coming into contact with vectors of zoonotic pathogens (Berg et al., 2001). However, there is a lack of information available for organic chicken and no information available for organic turkey. Thus, the objective of this study was to gain more information on conventional and organic whole raw retail chicken and turkey carcasses by comparing the microbiological quality.

Materials and Methods

Sampling of carcasses. Over a period of 12 months, 100 whole broilers and 50 whole turkeys were purchased from 3 retail stores in Knoxville, Tennessee. All of the broilers purchased were available to consumers. A total of 25 whole broilers from 4 different brands were purchased. Two of the brands were organically-reared chickens (assigned labels with A and B) and the other two brands were chickens raised conventionally (assigned labels C and D). For turkeys, a total of 25 organically-raised (assigned a label of A) and 25 conventionally-raised (assigned labels of B and C) were collected from the same retail stores. The whole broilers ranged from 2-7 pounds (900g-3,175 g), while the turkeys ranged

from 10-30 pounds (4,535 g-13,607g). All poultry carcasses were stored after purchasing at 4°C for 24-30 h.

Bacteria isolation. All bacteria from the carcasses were isolated using the FDA BAM protocol (FDA BAM 2011). Briefly, carcasses were removed from the package aseptically, placed in plastic bags and 400 mL of buffered peptone water (BPW; Becton Dickinson, Franklin Lakes, NJ) was added to the bag with the poultry carcass. The carcasses were then rinsed by inverting with an arcing motion continuously for 2 min. After rinsing, 50 mL of the BPW was aseptically removed from the bags and placed in 50 mL centrifuge tubes. The tubes were centrifuged at 8000 X g for 5 min. After centrifuging, the supernatant was discarded and the pellet was resuspended in 10 mL of BPW, followed by mixing with a vortex mixer until the pellet was dissolved. To isolate *Salmonella*, 1 mL of this suspension was inoculated into 9 mL Tetrathionate Broth (TET; Becton Dickinson). The TET tubes then were incubated at 37°C for 24 h and after incubation the samples were streaked onto XLT4 agar (Becton Dickinson) and incubated under the same conditions. Suspect colonies were passed onto tryptic soy agar (TSA; Becton Dickinson) and incubated under the same conditions. After incubation, colonies were confirmed as *Salmonella* using antisera (Statens Serum Institute, Copenhagen, Denmark) and also typed to serogroup. *Campylobacter*, *Staphylococcus spp.*, and aerobic bacteria from each carcass were quantified using standard methods. *Campylobacter* were quantified using *Campylobacter* Line Agar (Line 2001), aerobic bacteria were quantified using

plate count agar (Becton Dickinson) and for *Staphylococcus spp*., Baird Parker agar (Becton Dickinson) was utilized. Plate count agar plates were incubated at 30°C for 24 h and CLA plates were incubated in a microaerophilic atmosphere in an atmosphere controlled incubator at 42°C for 48 h. Baird Parker was incubated at 37°C for 48 h. To inoculate all three types of media, a 100 µL portion of the BPW suspension was used in a standard dilution series with BPW. Counts were calculated according to published protocols (Nanapenini et al., 2005).

Statistical Analysis. Analysis of variance was used to test for differences in means among several treatment groups and means were analyzed using a randomized complete block design in SAS 9.3 program. A P-value of <0.05 was used for the probability of statistical significance. The data were analyzed separately for the chickens and turkeys.

Results

For chickens, an organic product (brand D) had the highest mean count of aerobic bacteria, *Staphylococcus* spp. and *Campylobacter* (P<0.05), of the four brands of chicken evaluated (Figure 1A). However, brand C, also an organic product, had the lowest counts of aerobic bacteria, *Staphylococcus spp.* and *Campylobacter* (P<0.05). The two organic brands of chicken had statistically significant (P<0.05) differences in the mean counts of aerobic bacteria, *Staphylococcus* spp. and *Campylobacter.* In contrast, the two brands of conventionally produced chicken (A and B) were not statistically significant different for counts of the same bacteria (P>0.05). Only two of the chicken

carcasses tested positive for *Salmonella* and each was from one of the two organic producers. The *Salmonella* was serotype groups D and F.

Average counts of aerobic bacteria, *Staphylococcus* spp, and *Campylobacter* for the turkey carcass rinses were lowest for brand B, which was a conventionally-raised product (Figure 1B). The highest counts were for brand A which was an organic product. There was no statistically significant difference ($P>0.05$) in average counts of the aerobic bacteria, *Staphylococcus spp.* and *Campylobacter* between brands A (organic) and C (conventional) or between brands B (conventional) and C (conventional). However, brand A (organic) had higher mean counts for the same groups ($P<0.05$) than B (conventional). *Salmonella* was isolated from 2 turkey carcasses. Both carcasses were brand A and produced organically. Both *Salmonella* were serotyped as group D.

Discussion

In this present study, there was a higher recovery of *Campylobacter* from organic broilers and turkeys compared to the conventionally-raised products. This finding concurred with a study that reported the percentage of *Campylobacter* detected in slaughterhouses processing organic chickens was higher than those processing conventionally-reared chickens (Rodenburg et al., 2004). However, Hanning and others (2012) found levels of *Campylobacter* on both organic and conventional farms were similar thus concluding that rearing practices had no impact on *Campylobacter* prevalence in the farms sampled. Pereira and others (Pereira et al., 2009) reported that *Campylobacter* may be a

higher risk on organic versus conventional farms due to factors such as longer rearing periods which allows more time for colonization, and vulnerability of slow growing breeds of birds used for organic-rearing versus conventional Cornish-cross fast growing breeds. Additionally, birds reared on organic farms are more likely to come in contact with other animals and wild birds which are sources of *Campylobacter* (Pereira, et al., 2009).

The data collected in this study indicate that the organic brand of broilers had the lowest average levels of *Staphylococcus spp*. The reason for this is unclear. However, in general, *Staphylococcus spp.* may be more prevalent on whole broilers than other meats including beef and pork because the skin is left intact on poultry carcasses and the skin is a primary sight of colonization for *Staphylococcus* spp. (Hanning, et al., 2012). *Staphylococcus spp*. should not be overlooked as a foodborne pathogen as foodborne illness and outbreaks of due to *S. aureus* have occurred (Normanno, et al., 2007). Furthermore, methicillin resistant strains have been isolated from chicken which presents not only a risk of gastroenteritis but also a risk of skin infection from handling contaminated meats (Hanning, et al., 2012; Line, 2001; Normanno, et al., 2007).

Salmonella prevalence was low (5%) and the microorganism was only recovered from the organic brands of poultry. The available literature reporting *Salmonella* isolation from organic poultry and organic poultry farms agrees with our study. Heuer and others (Heuer, et al., 2001) reported a higher prevalence of *Salmonella* in conventional broilers compared to organic broilers. Bailey and

Cosby (Bailey et al., 2000) and Lestari and others (Lestari et al., 2009) reported a *Salmonella* prevalence of 31% and 21%, respectively, in organically raised poultry. Similarly, Melendez and others (Melendez et al., 2010) isolated *Salmonella* from 29.5% of organically-reared chickens and ducks. These studies reported higher prevalence rates of *Salmonella* in their samples than our data which indicates that other factors, such as production practices specific to the farm may be involved (Wang et al., 2013).

Seasonal effect is another factor that should be taken into consideration. A higher trend of *Salmonella* in raw retail chickens during the first quarters of a six year study was reported by Wilson and others (Wilson et al., 2002). However, this study also found that there was no seasonal relationship in the prevalence of *Campylobacter* in the chickens tested (Wilson et al., 2002).

To the best of our knowledge, this is the first study evaluating the prevalence of *Staphylococcus spp*. *Campylobacte*r and *Salmonella* in organic turkey carcasses. Only one study evaluating *Campylobacter* in organic turkeys was found, but this study evaluated *Campylobacter* from intestinal samples of organic and conventional turkeys, not carcasses (Luangtongkum et al., 2006). They reported high concentrations of the bacteria in both organic- and conventionally-reared birds. It is difficult to compare the present study with Luangtongkum and others (Luangtongkum et al., 2006) because of the sample type. However, the studies do agree that rearing practice did not have an impact on the levels of *Campylobacter* isolated from poultry. The current literature

indicates that *Campylobacter* is highly prevalent in all types of poultry regardless of the rearing conditions.

Conclusion

In conclusion, our data indicate that *Campylobacter* was prevalent in both organic- and conventionally-reared poultry. However, the organic poultry evaluated in this study did have a higher prevalence of *Salmonella* compared to conventionally produced poultry. Furthermore, organic turkey products evaluated had a higher prevalence of *Staphylococcus* spp. than the conventionally-produced turkeys. The present study indicates that organic poultry should not be considered safer in terms of microbiological quality than conventionally produced products and that microbiological quality appeared to be more dependent on the producer rather than the rearing practice.

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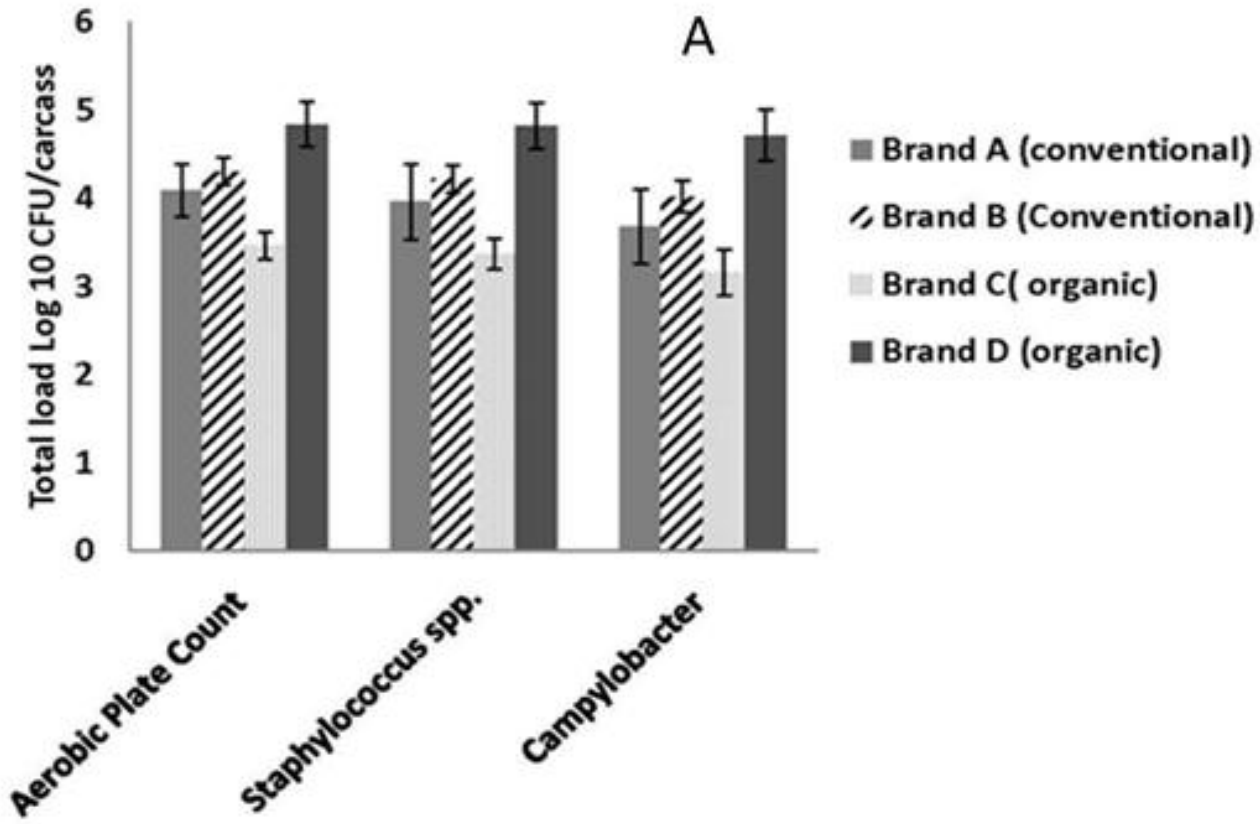
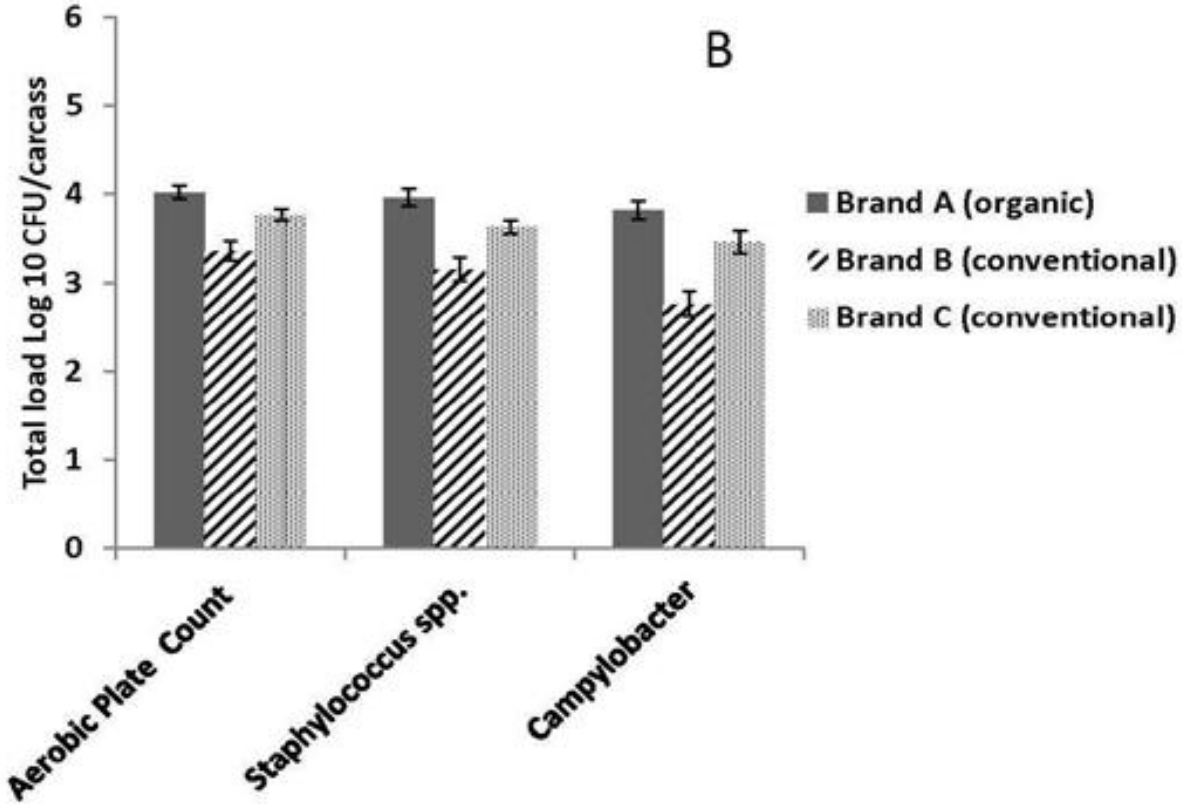
Figure 1. Total colony forming units (CFU) of aerobic bacteria, *Staphylococcus spp*., and *Campylobacter* per mL of rinsate collected from 100 raw broiler chickens (panel A) consisting of 4 brands (25 per brand) reared either conventionally (N=50) or organically (N=50) and 50 raw turkey carcasses consisting of 3 brands reared either conventionally (N=25) or organically (N=25).




B
Total load Log 10 CFU/carcass
6
5
4
3
2
1
0
Brand A (organic)
Brand B (conventional)
Brand C (conventional)
Aerobic Plate Count
Staphylococcus spp.
Campylobacter

APPENDIX

Whole carcass rinse

DAY 1

1. Record the brand of poultry and assign the numbers Chicken 1, 2, 3 and Turkey 1, 2, 3 with the dates in the format.
2. The whole bird is removed from package and then put in plastic bags aseptically for the shaking procedure.
3. 400 mL of BPW is added to the bags with the bird.
4. The bird is then shaken for two continuous minutes in an arching motion.
5. 50 mL of the BPW is then extracted from the bags and put in 50 mL tubes.
6. The tubes are then placed into the centrifuge at 8000rpm for 5 minutes.
7. After centrifuging the supernatant is discarded from each 50 mL tube leaving the 50 mL pellet.
8. 10 mL of BPW is then added to the pellet, followed by vortexing until the pellet is dissolved.
9. Tetrathionate Broth is then prepared by adding .2 mL of iodine solution to 9 mL of TET. One tube of TET is used for each sample.
10. 1 mL of each bird sample is then added to the TET tube.
11. The TET tubes are then placed in the incubator for 24 hours.
12. From the pellet solution .1 mL is inoculated onto the BP, PCA, and CLA plates.
13. For further dilutions, inoculate .1 mL into 900 µL of BPW to get -3.
14. Continue this step to get dilution desired.
13. After plating the BP and PCA are placed in the incubator at 37°C.
14. The CLA plates are placed into a microaerophilic incubator at 47 °C.

DAY 2

1. Plate count agar are counted.
2. XLT4 plates are streaked with the TET broth and then incubated for 37 °**c** for 24 hours.

DAY 3

1. CLA and BP plates are counted.
2. XLT4 plates are examined for colonies.

Collection of *Salmonella* and *Campylobacter*

1. Add1ml of Bolton/Brucella broth to the plate with the colonies.
2. Use loops to loosen the colonies
3. Draw up the colony liquid with a 1 ml pipette.
4. Add to labeled storage cryo tube
5. Add an equal amount of glycerol to tube and mix well
6. Store in -80 °C Freezer

VITA

Bridgshe' Hardy was born in Montgomery, AL. She graduated with a Bachelors of Science with a concentration in biology from Jackson State University. She continued to further her education at the University of Tennessee by entering the Food Science and Technology program. Her goal in life is to open a school on the border of Alabama and Mississippi devoted to teaching and helping obese kids lose weight and obtain a healthier, happier life while learning in a supportive environment.