# Walden University

College of Management and Technology

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John William Raede

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Review Committee
Dr. Charles Needham, Committee Chairperson, Doctor of Business Administration Faculty

Dr. Judith Blando, Committee Member, Doctor of Business Administration Faculty

Dr. Kevin Davies, University Reviewer, Doctor of Business Administration Faculty

Chief Academic Officer
Eric Riedel, Ph.D.

Walden University
2013

Abstract

Effects of a Supplier Improvement Program on a Global Supply Chain

by

John William Raede

MAOM, University of Phoenix, 2002

BS, California Polytechnic State University at San Luis Obispo, 1990

Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Business Administration

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Abstract

Food-borne illnesses cause approximately 300,000 hospitalizations and 5,000 deaths every year in the United States. The purpose of the study was to examine a major concern among food processors, which is how to reduce food-borne illness and injury resulting from supplier quality incidents. The theoretical framework for the study was the supply chain management model, which coincides with supplier quality programs implemented by food processing companies. The research question addressed whether a causal-comparative relationship existed between the implementation of a supplier improvement program and supplier quality incidents. Archival supplier quality incident data were collected from a food processing company (FPC) located in the United States. Statistical analyses were conducted using a paired samples t test, which indicated a significant reduction in supplier incidents after the implementation of the supplier improvement program. FPC owners and managers could use the results of the study to develop and execute a supplier improvement program to reduce the amount of supplier-related quality incidents. These findings suggest that food-contact packaging companies may incorporate the validated process control data into practices that reduce food safety risks associated with food packaging. The implications for social change include the potential for a safer supply of food and an increase in consumer confidence in processed foods. Consumer preferences may change regarding flavor profiles, convenience, and price point. These findings may engender positive social change by creating an environment where consumers do not have to determine whether a food product might cause illness.

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Dedication

This project is dedicated to every food safety professional who quietly and humbly strives to provide a safe and wholesome product to their customers, consumers, family, and friends.

Acknowledgments

I acknowledge my incredible family that pushed, prodded, praised, and performed in a manner that kept my focus on the goal. In addition, I acknowledge Dr. Charles Needham, my committee chairperson; Dr. Judith Blando, my second committee chairperson; Dr. Kevin Davies, my university research reviewer; and Dr. Freda Turner, program director, for their tireless dedication and inspiration. On that premise, I am compelled to acknowledge an incredible source of inspiration for me in the times I doubted I could complete the project, and that is our brave men and women who are either serving or have served in the U.S. Armed Forces.

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# Section 1: Foundation of the Study

In 2010, the leadership of a food-processing company (FPC) implemented a program to achieve zero tolerance standards for supplier-generated quality incidents mandated by the global corporate office (GCO). The management of the FPC developed the program to help suppliers identify processes that generated quality issues, using a supplier incident database that recorded incoming supplier quality incidents at five frozen-meals factories. The information in the database enabled the managers to perform trend analyses regarding supplier incidents. The mandate for the program changed from reacting to supplier incidents to preventing supplier incidents.

The intent of the study was to determine if a relationship exists between the supplier improvement and supplier quality incidents. The supplier management program targeted the top 20 suppliers responsible for quality incidents. Quality assurance employees for the FPC used a software application to record the quality incidents and e-mails to inform the suppliers responsible for the noncompliance issues. The scorecard system is a valued tool to track and display supplier performance targeted goals (Carbone, 2009). The employees of the FPC relied on the suppliers to research the cause of the incidents and create corrective action procedures. The quality incident program achieved a limited success rate.

Stagnation in defect levels occurred after initial progress toward reducing supplier quality incidents. The leaders of the FPC realized the need for a supplier improvement program to decrease supplier-related quality incidents. A division-level director of quality management received instructions to create a process focused on working with suppliers to reduce quality-related incidents. The new process was referred to as the *supplier management and improvement program*. As in any new program, questions arose regarding the effectiveness of the program.

## Background of the Problem

In 1988, the United States Department of Agriculture (USDA) mandated a program referred to as Hazard Analysis Critical Control Point (HACCP) that focused food-processing companies on performing self-evaluations of processes (USDA, 1996). HACCP programs require quality assurance professionals (QAPs) to identify points in the process that, if not monitored properly, could cause food-borne illness by a harmful microbial pathogen (*Listeria*, *Salmonella*), chemical contamination, or physical choking hazards (USDA, 2010). In the United States, the incidence of food-borne illnesses linked to microbial contamination (e.g., *Escherichia coli*, *Salmonella*, and *Listeria*) dropped from 63,000 cases in 1992 to 23,000 cases per year in 2009 (Centers for Disease Control and Prevention [CDC], 2012). The net cost to the food industry decreased from $1.2 billion to $700 million, according to the CDC in Atlanta, Georgia (CDC, 2010).

The FPC in this study implemented a HACCP program in 1989 for each of its five frozen food factories and by 1995 began to focus on the supply chain. The quality of the finished product is interdependent on the raw materials used in the process (De Laurentis, 2009). The FPC became aware of the relationship between ingredients and the finished product through a series of supplier-initiated critical failures. Conducting supplier quality audits to ensure a sustainable source of ingredients is an important component of a total quality management system (Taylor & Taylor, 2008).

In 2003, the FPC's management understood the need to perform quality audits at the suppliers' factories to validate the HACCP program's effectiveness in preventing critical failures. Doherty (2011) argued the point that using quality audits to ensure a wholesome finished product

requires focus from quality assurance professionals. With more than 2,000 suppliers to audit, the use of quality assurance managers (QAMs) to conduct audits could cause disruption of normal duties. The management of the FPC realized that the volume of suppliers that required auditing would place a burden on the QAMs and displace the focus required to operate within the business units. In 2004, the leaders of the FPC hired 10 quality assurance professionals (QAPs) to perform supplier quality audits.

In 2007, the management of the FPC recognized that the volume of critical failures caused by supplier ingredients had reduced by 75%; however, the financial severity of the incidents of critical failures had increased by 300%. The management of the FPC recognized the benefit of a reduction of incidents; however, the increase in the severity of the remaining incidents created a different challenge. The leaders of the FPC realized the need to strengthen the relationship with the supply chain to reduce the financial burden and food safety risks associated with critical failures. A need to develop a relationship based upon shared knowledge and accountability is a cornerstone for creating a viable and profitable supply chain (Myers, 2008).

An increased financial burden on the FPC because of supplier critical failures caused the leaders of the FPC to pursue additional measures to address the supplier incidents. The financial strength of a manufacturing company is the quality of products produced and the ability to meet the demands of the consumer base. If the raw materials are defective, the product will fail to meet the consumers' expectations and cause potential liability (Boyle, 2009). Defects identified in the finished product prior to distribution become more expensive when the product reaches the retail consumer. The least costly method is to prevent the defect from reaching the factory receiving

department. Suppliers that increase *positive release programs* can prevent defects from reaching customers' manufacturing locations (Myers & Cheung, 2008; Weise, 2008). .

## Problem Statement

In 2009, nine deaths and 550 illnesses attributed to *Salmonella* contamination in peanuts used for making peanut butter caused the largest food industry recall in the history of the United States (CDC, 2010). The recall of 3,900 products affected 200 companies, costing over $500 million. Representatives of the CDC in Atlanta, Georgia, reported in 2010 that 48 million Americans may have suffered from domestically acquired food-borne illness associated with ingredients purchased through a supply chain (CDC, 2011). The general business problem was that food-borne illnesses cause approximately 300,000 hospitalizations and 5,000 deaths every year in the United States (CDC, 2011). The specific business problem affecting an FPC was how to determine if a supplier improvement program was successful in reducing supplier-related food safety incidents.

## Purpose Statement

The purpose of the quantitative, causal-comparative study was to examine if a supplier improvement program influenced supplier-related food safety incidents. The basis for the quantitative, causal-comparative study was an ex post facto examination of numeric data to determine if a cause-and-effect relationship existed between an intervention (supplier quality improvement program) and a dependent variable (supplier quality incidents). The FPC is in the United States; however, the FPC sources ingredients from a global supply chain. The vice president of quality assurance for the FPC granted permission to use specific data from the quality incident vendor complaint database (VCD). Quality incident data were collected by the

employees of the FPC and entered into the VCD. The specific population consisted of 2,000 ingredient suppliers for the FPC. The VCD database consisted of ingredient suppliers' quality-related incidents, and the selected data encompassed a 5-year period from 2007 to 2011. The results of this study highlighted additional resources for food-processing companies to determine the best method to reduce potential food safety hazards initiated by the supply chain from reaching the consumer. Gülgün and Gülçin (2010) concluded that the effect of a supply chain on a business is critical to the success or failure of the enterprise.

## Nature of the Study

This quantitative causal-comparative study was an examination of parametric data. Parametric methods use normal distributional assumptions (Scallan, 2011). The FPC data were normal statistical distribution (parametric) based on analysis of the data provided for the research project. Theoretical distributions are based on statistical quantities called *parameters* that refer to the mean and standard deviation (Simon, 2006). A quantitative method was performed because qualitative research is used to gain an understanding of human behavior (Scallan, 2011). I was not concerned with the human behavior aspect of supplier improvement in the study. The analysis, interpretation, and conclusions of the study were based on numeric differences expressed in the frequency of supplier incidents increasing or decreasing after the intervention. A quantitative causal-comparative study was an appropriate method to determine if a cause-and-effect relationship existed between variables (Cláudia, Sarrico, & Rosa, 2009).

The design of the study was causal-comparative and coincided with the purpose of the research project. In a causal-comparative study, the researcher seeks to determine if an ex post facto cause-and-effect relationship exists between dependent variables and a treatment or test

(Scallan, 2011). In a correlational design, the researcher examines two or more variables in one group (Simon, 2006). The focus of this study was examining one variable in two groups: supplier incident data (dependent variable) before and after a supplier improvement program (intervention).

## Research Question

The research question of this study concerned whether a supplier improvement program (intervention) affected or influenced supplier incident data (dependent variable) for an FPC operating in the United States of America.

## Hypotheses

The purpose of the study was to examine supplier incident data (dependent variable) before and after a supplier improvement program (intervention) to determine if the program affected or influenced the supplier incident data. The use of quantitative hypotheses allowed my prediction of the relationship of the variables to identify the direction of the study (Firestone, 1989).

The hypotheses were as follows:

$H1_o$: There is no statistical difference on supplier incidents with a supplier improvement program.

$H1_a$: There is a statistical difference on supplier incidents with a supplier improvement program.

## Theoretical Framework

The theoretical framework for the study was the Toyota Motor Company's (TMC) supply chain management model. In 1951, Sakichi Toyoda created a business model that involved

coordination with suppliers to deliver defect-free components at the required time, a process referred to as *Kanban* (Bandyopadhyay, 2007a). The employees of the TMC use the model to focus on improving the quality of incoming products provided by the supply chain. Sakichi Toyoda's concept of quality focused on the individual parts that make up the finished product. Toyoda visualized an affordable vehicle, using highly trained employees to assemble components of consistent quality (Bandyopadhyay, 2007b).

Preventing failure within the supply chain is the most effective means of averting the potentially costly impact of process deviation (Kumar, Chloe, & Venkataramani, 2013). Food-processing companies rely on the quality of the ingredients and packaging materials received to ensure a wholesome product. In essence, food processors assemble frozen meals from ingredients they receive from suppliers, similar to the automotive industry. Kumar et al. (2013) stated that the benefit of providing components directly to production lines, at the exact time required, and assembling the product is a universal concept in manufacturing. The strength of the supply chain is a critical pillar in the general sustainability of a business. A manufacturing company requires raw materials to arrive in compliance with regulatory agencies, company specifications, and consumer requirements (Mitchell & Gruler, 2008).

Supplier performance equates to the total quality of the finished product (Lewis, 2008). Implementing preventive measures to reduce or eliminate supplier-generated quality issues creates an immediate effect on the final quality of the product. Lewis (2008) stated further that one method to identify incoming ingredient defect levels is to implement an acceptable quality limit (AQL) program.

## Definition of Terms

*Acceptable quality limit (AQL):* The AQL was developed by the United States of America Military. An AQL establishes the maximum percent defect level (or the maximum number of defects per hundred units) for sampling inspection and is considered satisfactory as a process average (Leedy & Ormrod, 2010).

*Brand equity:* Brand equity is a term used in the marketing industry describing the value associated with a well-known brand name. The owner of a well-known brand name can generate more money from products with that brand name than from products with a lesser known name (Matyusz, Demeter, & Csenge, 2012).

*Certificate of analysis (COA):* Customers of further processors use COAs in the food industry to validate that the physical, chemical, and biological characteristics of the ingredient comply with the specifications (Hwang, Radhakrishnan, & Su, 2006).

*Extraneous vegetable material (EVM):* EVM is a term used to describe undesired vegetable matter associated with harvesting and processing vegetables. EVM normally consists of stems, seeds, leaves, and unsalable plant material (Sams, 2011).

*Food and Drug Administration (FDA):* The FDA is an agency within the U.S. Department of Health and Human Services. The agency consists of the Office of the Commissioner and four directorates overseeing the core functions of the agency: medical products, tobacco, foods, global regulatory operations, and policy (Hanacek, 2011).

*Food-processing company (FPC):* FPC is a general term used in the study referring to the subject of the research project to maintain the anonymity of the company (Ethan, 2007).

*Foreign material (FM):* A solid matter in or on an ingredient not identified within the ingredient statement of the certificate of analysis (Tang, 2008).

*Further processors (FPs):* Further processors assemble ingredients into frozen meals sold to consumers. The consumer is required to reheat the meal (Kumar et al., 2013).

*Genba*: A Japanese term for physically walking the factory floor to see a problem in a manufacturing environment. The process enables the management group to fully understand the issue prior to developing a corrective action plan (Imai, 1997, p. 123).

*Global corporate office (GCO):* GCO is an acronym that has been created to protect the identity of the company in this study. The acronym represents the headquarters in central Europe, which mandates operating procedures for the regional business units (Ethan, 2007).

*Global Food Safety Initiative (GFSI):* The GFSI was founded in 2000 with a focus on improving food safety systems by benchmarking existing food standards (Stier, 2011b).

*Hazard analysis critical control point (HACCP):* HACCP is an approach to food safety that focuses on physical, chemical, and biological hazards to establish procedures aimed at prevention rather than finished product inspection (Fotopoulos, Kafetzopoulos, & Psomas, 2009).

*High hydrostatic pressure (HHP):* This process involves the placement of sealed packages containing food into a cylindrical pressure vessel. Water is added, and the vessel is closed. The vessel contents are pressurized at levels up to 87,000 pounds per square inch (D'Souza, Su, Roach, & Harte, 2009).

*Interpretative structural modeling (ISM):* This program is based upon evaluating and developing competitive pressure, incentives, supplier development programs, the buyer-supplier

relationship, buyer-supplier communications, supplier performance, and buyer performance (Govindan, Kannan, & Haq, 2009).

*Kanban:* A method developed by the Toyota Motor Company to ensure that its suppliers deliver defect-free components to the manufacturing site at the required time (Bandyopadhyay, 2007a).

*Lot code:* A lot code is a numeric descriptor used in the manufacturing industry to identify the day, month, and year a product was produced. Lot codes may reflect the location, manufacturing line, and shift during which the product was produced (Bayo-Moriones, Bello-Pintado, & Merino-Diaz-de-Cerio, 2011).

*Positive release program:* A positive release program requires employees to restrict shipment of finished goods to the customer until the quality assurance team reviews the results of specific food safety related tests and releases the products (Weise, 2011).

*Pulsed electric fields (PE):* PE is a non thermal method of food preservation that uses short bursts of electricity for microbial inactivation and causes minimal or no detrimental effect on food quality attributes (D'Souza et al., 2009).

*Quality assurance professional (QAP)*: A quality assurance professional is a person certified by the by the American Society of Quality (Tang, 2008).

*Quality auditing:* Quality auditing is a function of a supplier management program tasked to inspect supplier locations using baseline criteria to evaluate the procedures and processes of a supplier (Mitchell & Gruler, 2008).

*Stockout:* A condition in which a routinely available item is not in inventory at a retail store that causes the consumer to search for an alternative item (Turk, 2012).

*Structural equation modeling (SEM):* SEM is a statistical technique for testing and estimating causal relations using a combination of statistical data and qualitative causal assumptions (Sagheer, Yadav, & Deshmukh, 2009).

*Supplier scorecard:* The scorecard system is a valued tool to track and display supplier performance targeted goals (Carbone, 2009).

*Third party auditor (TPA*): A third party auditor is employed by a quality-auditing company to perform audits for companies that do not employ auditors in a full-time capacity (Burns & Fogarty, 2010).

*U.S. Department of Agriculture (USDA):* The United States of America Department of Agriculture is the federal executive department responsible for developing and executing U.S. federal government policy on farming, agriculture, forestry, and food (USDA, 2010).

*Vendor complaint database (VCD):* The VCD is a database constructed by the FPC to record supplier quality incidents at the factory level. Manufacturing companies require data to evaluate a supply chain for strength and weaknesses. Supplier incident data may aid in identifying suppliers to terminate contracts with and suppliers that should be provided financial incentives as a reward for excellent performance (Berzau, 2011).

## Assumptions, Limitations, and Delimitations

### Assumptions

The study did not contain participants or surveys. Numerous assumptions were inherent in the study. Assumptions were in relation to an existing dataset. The first assumption was that the data were correct and associated with the proper supplier. The second assumption was that the supplier incident occurred or was caused by employees of the FPC. The third assumption was

that the supplier provided the ingredient correctly associated with the incident. The fourth assumption was that the supplier was an active participant in the supply chain for the FPC, and the fifth was that the data were considered parametric because of a normal distribution.

**Limitations**

The study was limited to a specific company and a finite dataset. The results of the study are not applicable to a larger population of manufacturers because of the specific processes associated with food processing. Ingredient suppliers for a food processor are required to comply with restrictions and specifications that a generalized manufacturing company might not follow. The potential amounts of variables were not attributed to supplier-generated quality incidents.

The focus was limited to suppliers and incidents within the specific dataset. The dataset reflected incidents regarding agriculture-based ingredients (such as vegetables, meat, and dairy). In the study, the focus was on supplier-generated defects addressed and corrected through process improvement practices, and not on extraneous influences on food ingredient quality such as cost variations based on shortages and diminished quality attributes from ecological damage.

The results of the study do not apply to general manufacturing industries because of the external variables associated with food ingredients. Food processing companies are inhibited by a specific condition inherent to the food processing industry. Food ingredients are susceptible to shelf-life constraints not experienced by other types of manufacturers (e.g., automotive, computer, machinery). The FPC purchases 98% of the ingredients from intermediary processors, who purchase or harvest raw materials. An attempt to correlate the specificity of the dataset provided by the FPC to a different type of manufacturing business might have caused dilution of the results.

### Delimitations

The FPC in the United States delimited the scope of the research and did not encompass the global organization. The focus was limited to one approved dataset. The basis for the research was supplier incidents from 2007 to 2012 within the dataset. The amount of information gathered within a 6-year period represented by a fixed number of suppliers was a delimitation. The dataset consisted of 2,000 food ingredient suppliers, and additional data did not become available.

## Significance of the Study

### Contribution to Business Practice

For the past century, consumer safety in relation to food distribution has remained a national concern (Tang, 2008). The population of the United States of America evolved from an agrarian society that harvested and prepared food raised for consumption to a populace that relies on food processors to prepare ingredients up to final heat application (Gomy, 2011). The transition has forced food processors to implement stringent food safety practices to compensate for the consumer's lack of basic food safety principles. Gomy (2011) asserted that consumers are reliant on food processors to ensure that consumers do not become ill from ingredients that are not wholesome.

The intent of the study was to provide an examination of the effectiveness of a supplier improvement program designed to reduce risks associated with a supply chain that may injure or cause illness to consumers. In 2011, the impetus of the food industry changed from reaction to prevention. Prevention programs evaluate reductions in the risk of food-borne illnesses (Ficke, Myrick, & Hansen, 2007). A properly vetted food safety program decreases the opportunity for

critical food safety failures associated with consumer products (Tang, 2008). The quality assurance professional (QAP) must focus on identifying practices and procedures within the process that may contribute to food-borne illness and eliminate them (Berzau, 2011).

**Implications for Social Change**

Food-processing companies have an inherent responsibility to provide a safe and wholesome product to the consumer. The main purpose of a food-processing company is to provide products consumers can trust with wholesome, nutritious, and safe ingredients (Scharff, 2012). The focus of the research was to examine the effectiveness of a preventive program that may aid food-processing companies in reducing food-borne illness and injury to consumers caused by supplier ingredients.

If a food-processing company is continually experiencing food safety-related issues deriving from the supply chain, the focus of the operation may become reactionary as opposed to preventative (Burns & Fogarty, 2010). Strengthening the supply chain of a food-processing company to ensure a sustainable source of safe ingredients allows the processor to focus on cost savings and product improvements. Kilwald (2010) posited that when a food-processing company adopts a preventative food safety strategy, the consumer benefits by purchasing a safer product. The management of the FPC examined the importance of transitioning from reacting to critical failures within the supply chain to taking a preventative approach. Complying with the preventative approach, the management of the FPC implemented a supplier quality-auditing program and a supplier improvement program.

## A Review of the Professional and Academic Literature

Increased concern about the safety of the global food supply has led to the revelation of critical failures within the supply chain (Kumar & Schmitz, 2011). The literature review is focused on ensured supply, industry weaknesses, process validation, and prevention practices. The purpose of the literature review was to provide an overview of peer-reviewed journal articles, academic studies, and government documents related to implementing food safety improvements. The three databases used for the study were ABI/INFORM Complete, Business Source Complete/Premier, and Emerald Management Journals. The keywords used were *supply chain quality, quality assurance, quality auditing, supply chain management, hazard analysis, critical control points, and food safety.* The primary focus of the review was providing articles and studies focused on four distinct areas of supply chain management: global supply chain transportation strategy, challenges facing the food industry, quality auditing, and supplier improvement programs.

### Global Supply Chain Logistics

The management of the FPC began to view logistics as more than a source of cost savings. Logistics is a competitive advantage; it provides means of enhancing products and increasing consumer satisfaction. Logistical planners for the FPC developed a global supply chain to ensure a consistent supply of fresh ingredients. The ability to source ingredients from a global supply chain and deliver products to the desired manufacturing location at a competitive cost creates an advantage in the marketplace (Sakchutchawan, 2012). One interpretation of the process view of business might imply that connections between individual processes such as order fulfillment and supplier development are not critical. An accurate representation of how a

business generates value by acting as an integrated component in the supply chain (Huq, Stafford, Bhutta, & Kanungo, 2010).

Performance improvements in a supply chain may increase through the integration of material and information exchanges between companies. Sakchutchawan (2012) stated that investments in supply chain management technologies have improved financial performance metrics for incoming and outgoing processes. Investors need to align with business processes and objectives to deliver projected profit benefits at the factory level (Myers & Cheung, 2008).

The FPC sources ingredients from 2,000 suppliers from 35 countries on four continents (see Figure 1). Partnering with global vendors may pose challenges to ensure a consistent supply of wholesome ingredients that comply with specifications, consumer expectations, and local regulatory agency requirements. Assembling a supplier network capable of consistently providing the correct ingredient within the timeframe required may become a challenge based on the logistical requirements (Skapa & Klapalová, 2012).

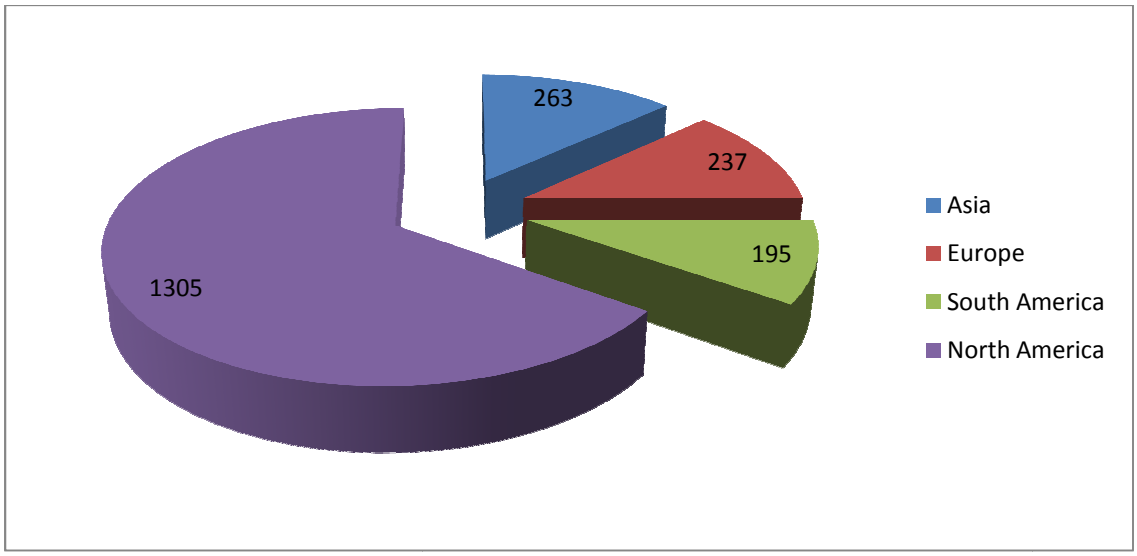

*Figure 1.*Supplier continent of origin pie chart. The chart was created to display the numbers of suppliers on the four continents identified. The largest volume of suppliers operates out of North America (1,305), followed by Asia (263), Europe (237), and South America (195).

The suppliers for the FPC use four means of transporting ingredients into the frozen-meals factories in North America: air freight, ocean shipping container, railcar, and trucking. Shipping ingredients by aircraft is expensive and may cause logistical barriers inherent to the air freight industry. Regulatory agencies increased restrictions and oversight policies after September 11, 2001 (Yang, Hui, Leung, & Chen, 2010). The FPC uses air freight for specialty ingredient items that are difficult to source. Often, proprietary ingredients essential to matching desirable consumer flavor profiles require sourcing items from remote suppliers in small quantities (less than 50,000 lbs./year).

Transporting ingredients by ocean container is an economical and frequently used method of shipping a broad spectrum of goods on a global scale (Creazza, Dallari, & Melacini, 2010). The FPC receives a majority of its frozen vegetable ingredients processed in South America and China via ocean container transport. Special considerations and conditions are required by the FPC to ensure that the vegetable products are maintained at the optimum temperature range for flavor and wholesomeness. Vegetable suppliers for the FPC perform strict pathogen testing procedures prior to shipping the products. A composite sample of each lot code is sent into the microbiological testing lab of the FPC. Once the test results are concluded, the product is either released for shipping or rejected.

The management of the FPC requires frozen product to maintain at a temperature of zero degrees Fahrenheit during the transportation and storage phase. Digital temperature recorders are

placed at strategic locations within the containers, where they record temperature variations throughout the duration of the transport. If product abuse is suspected, the digital recorder data were downloaded and analyzed by an employee of the FPC. The data derived from the temperature recorder displayed the ambient temperature of the container throughout the travel time (Lis, Gourley, Wilson, & Page, 2009).

The FPC receives the majority of its ingredient shipments by truck and railcar. Railcar is considered an economical method of transportation if the destination point is in proximity to a rail spur (Myers & Cheung, 2008). A negative condition associated with railcar is shipping-container damage. The raw material-receiving employees of the FPC reported in 2010 that 40% of shipping-container damage was attributed to railcar shipments.

Trucking is a fundamental component of supply chain management and represents 95% of transportation costs for manufacturing companies (Alex da, Näslund, & Jasmand, 2012). The transportation logistics industry is striving for complete integration of routing efficiency software (Manuj & Mentzer, 2008). Advances in software and communications links have reduced issues involved with integrating supply chain systems. Transportation management systems aggregate data and display the results to provide complete visibility of information available for logistics decisions (Carl, Cahill, Goldsby, & Knemeyer, 2010).

Theft of and tampering with ingredients during transport are concerns for the management of the FPC. Raw material-receiving employees of the FPC perform an inspection of the shipping trailer when a shipment arrives to a frozen-meals factory. Employees validate that the trailer seal is intact and the shipping seal number on the trailer matches the number identified in the shipping documents. The inside of the trailer is inspected for damage, cleanliness, and

odors prior to unloading the cargo. The employees of the FPC are required to perform the inspections to ensure that the incoming ingredients are wholesome and unadulterated during the transportation process. Product safety begins at the supplier's manufacturing location and must continue to the consumer's home (Liddle, 2010).

**Food Industry Challenges**

The challenge of the food-processing industry is to secure safe and wholesome ingredients to produce products that consumers demand. Individual food-processing companies are becoming knowledgeable of the influence that the supply chain has on product quality (Boyle, 2009). The FPC is aware of the influence the supply chain has on product quality. Cafaggi (2011) posited that developing a secure and sustainable ingredient supply chain must align with the operating plan of food-processing companies.

Food-processing companies must comply with increasing regulatory requirements while maintaining a profitable position in the marketplace. Regulatory compliance has driven the food-processing industry to work more closely with ingredient suppliers to increase the level of internal specification and regulatory compliance (Stringer, Sang, & Croppenstedt, 2009). Based on the complexity of the ingredients and implementation, validating the individual efforts of contributors to a company's supply chain may prove difficult. A supply chain may prove sustainable when the goal of the participants is a relationship based on shared knowledge and focused on the satisfaction of the consumer (Sams, 2011).

The expectations of the food-processing industry are to produce a safe and nourishing product. Excessive processing of ingredients destroys nutrients and beneficial enzymes at the high temperatures required to kill lethal pathogens (Wang, 2012). The ability of a food processor to

balance food safety and provide a product that contributes to the general health of the consumer is an achievable goal (Liddle, 2010). Consumer preferences are changing from highly processed frozen entrees to minimal processing with natural freshness and flavor. Food-processing companies are searching for alternative methods to ensure consumer safety and meet consumer demands (Thorndike, Sonnenberg, Riis, Barraclough, & Douglas, 2012).

Microbiological pathogens accounted for 87% of food product recalls in 2008 (CDC, 2009). The optimal temperature range for a pathogen to survive is between 40°F and 140°F, and an application of heat is the standard method used by food-processing companies to eradicate pathogens from food (Rodrigo, Sampedro, Silva, Palop, & Martínez, 2010). Foods that contain high water content lose valuable nutritional properties when heat is applied. Emerging food preservation processes are developing to satisfy consumer preferences for minimally processed foods with natural properties (Rodrigo et al., 2010).

The use of high hydrostatic pressure (HHP) and pulsed electric fields (PEF) can provide a viable alternative to heat application processing (CDC, 2011). The quality advantages for industrial applications are expanding, and food industry professionals (D'Souza, Su, Roach, & Harte, 2009) consider both processes economical. Damage to cell membranes, enzymes, or DNA is the cause of microorganisms' death with these technologies (CDC, 2012). Within a population of microorganisms, the HHP process effectively kills 85% of the organisms. The remaining 15% is a damaged population that may survive and cause illness to a consumer (D'Souza et al., 2009).

Pulsed electric fields and HHP technologies require extensive evaluation by the food-processing industry and regulatory agencies (CDC, 2012). Once the investigation and validation criteria are satisfied, food processors may use consumer taste panels to determine if the

pasteurization process altered the flavor profiles (Das, 2011). Manufacturers of PEF and HHP technology must work closely with the food-processing industry to ensure the equipment is safe for employee operation and affordable for processors to purchase (Rodrigo et al., 2010).

Food safety is the responsibility of the food-processing company and not the regulatory agencies because regulatory agencies do not manufacture the products (Das, 2011). Food-processing companies are morally and financially accountable processed foods that may cause food-borne illnesses (Stier, 2009). Regulatory agencies set baseline standards of food safety for food-processors to follow; however, food-processing companies are responsible to execute against the standards (Nganje, Miljkovic, & Ndembe, 2010). The 2010 recall of whole eggs contaminated with salmonella is an example of failed execution of regulatory standards. The egg processing company operators ignored existing food safety policies, and the FDA inspectors failed to observe the deficiency (Das, 2011).

Creating a collaborative approach to food safety using regulatory resources and designing effective procedures requires a mixture of industry and regulatory consideration (Suddath, 2010). Continuing a practice of implementing regulatory and business symposiums to address compliance issues may strengthen the relationship between agency and industry. A balance must develop between agency regulations and the private sector companies' abilities to improve upon the baseline regulations and monitor processes (Mitchell & Gruler, 2008).

Suddath (2010) discussed the inception of the food industry regulatory agencies and the impact of increased regulation and the positive effects on the reduction of food-borne illness cases. Industry professionals and regulatory agencies must use a balanced approach to develop cogent and effective operating procedures to prevent critical failures (Soltani, Azadegan, Liao, &

Phillips, 2011). Food safety management is more important than the financial management of a company (Stier, 2011a). The financial implication of producing an unsafe product distributed to a broad consumer base creates the potential to affect an individual company and critically damage a sector of the food industry (Andotra & Pooja, 2009).

One example is the case of Peanut Corporation of America's (PCA) bankruptcy because of peanuts contaminated with salmonella entering into the supply chain. The recall, fines, and subsequent lawsuits forced the owner PCA to shut down the operation, and the negative effects translated into an immediate 27% reduction in peanut butter sales in the United States of America ("Recipe for Safer Food," 2009). Hwang et al. (2006) discussed the need for balance in food-processing companies' internal quality procedures to comply with regulatory agencies. The FPC understood the importance of monitoring processes for food safety improvement to ensure the procedures exceed regulations established by the FDA and USDA. Failure to self-monitor leads to critical failures and eventual consumer demands on federal agencies to implement additional regulations. An additional strategy to self-monitoring is for food processors to enroll suppliers in standardized food safety procedures and validate compliance (Olson, 2011).

The ability for a food processor to secure a supply chain that provides wholesome products in an uninterrupted managed process will determine the sustainability of the company (Akkerman, Farahani, & Grunow, 2010). As an example, the pharmaceutical industry is a highly regulated business and increasingly dependent upon supply chains (Van Arnum, 2011). Managers of companies in the pharmaceutical industry require the suppliers to develop and adhere to strict ingredient validation procedures (Xu, 2011). The development of extensive

validation procedures and ingredient measurement systems ensure consistent ingredient quality (Davis, 2007).

Consistent ingredients ensure a stable product that consumers anticipate when purchasing from the manufacturer (Wechsler, 2011). Within the food-processing industry quality workshops and food safety councils are important to achieve consistent quality (Yasuda, 2010). As an example, government backed regulatory agencies can implement aggressive planning to minimize fragmentation of compliance and fortify industry-derived solutions. The impetus remains on the food processor to comply with regulatory requirements and meet the expectations of the consumers for quality and price (Shames, 2011).

The effectiveness of the regulatory agency systems and the impact on commercial operations' contributes to the regulatory creation process (Yasuda, 2010). Developing a relationship based on trust is a difficult undertaking when regulatory agencies mandate manufacturing constraints on industry (Kumar, Choe, & Venkataramani, 2013). Perceptions of regulatory oversight restricting efficient production models can cause processing companies to comply with minimum regulations (Arpanutud, Keeratipibul, Charoensupaya, & Taylor, 2009).

The advancement in food safety technology, ranging from optical scanners designed to remove foreign material (FM) to 24-hour pathogen test results, are narrowing the gap between regulatory mandates and full compliance (Rodrigo et al., 2010). Maintaining a comprehensive program to investigate, test, and employ advanced technologies to ensure food safety is a vital part of an eclectic approach toward full regulatory compliance and consumer satisfaction (Olson, 2011).

**Quality Auditing**

Since the inception of HACCP in 1988, the need to validate process control procedures created the quality-auditing process (USDA, 2010). Officers in the United States Army Food Service Program (USAFSP) developed the quality-auditing format in 1985, and subsequently adopted throughout the food industry (Stier, 2009). The Army Officers developed a quality-auditing program to ensure the food service providers of the Army were compliant to the regulations (Riell, 2002).

Quality-auditing evolved into two distinct methods of implementation: employees or in house, and contracted or third party (Knight, 2011). The concept of a third party auditor evolved because of the financial constraints of smaller companies to afford full-time quality-auditing department (Arpanutud et al., 2009). Third party auditing companies can provide a least cost method for additional assurances the supply chain is compliant to food safety regulations (Stier, 2011b). The FPC employs 10 auditors to perform 95% of the required audits of the supply base. The remaining 5% of suppliers manufacture a low risk ingredient and are not required to comply with an annual audit. The management of the FPC accepts third party audit reports for low risk suppliers.

The development of external quality audits in the automotive industry evolved from performing quality audits of incoming raw materials to conducting quality process audits at the suppliers' manufacturing locations (Bandyopadhyay, 2007a). Quality audits are a valuable step to reduce defects arriving at the automotive assembly plants. Performing quality audits at the suppliers' location may strengthen supplier-customer relationships for businesses that rely on trust as the base premise (Androta & Pooja, 2009). When a customer can understand the

suppliers' process, the customer gains an increased level of understanding of the challenges faced by the supplier (Bandyopadhyay, 2007b).

Working with suppliers to tighten manufacturing specifications and release procedures could decrease supplier related defects (Androta & Pooja, 2009). Using technological advances in software to develop specifications, AQL procedures, and supplier quality audits may benefit participants of a supply chain to eliminate waste. The use of technology to increase productivity and leverage cost savings, can increase supplier sustainability (Bandyopadhyay & Jenicke, 2008).

The advent of computer software to enter inspection data, track corrective actions, and schedule future audits streamlined the process to drive efficiency as demand for audits increases (Shih, 2009). The increase in demand caused a deficiency of qualified personnel to conduct quality audits. Managers in the food industry are struggling to provide an environment to attract college graduates with a technical and science background to comply with the current demand (Penini & Carmeli, 2010).

Quality auditors rely on processing experience when performing audits. Knight (2011) stated that an effective quality auditor could leverage process knowledge against observations within the guidelines of the audit focus (Johnson, 2011). Auditors that have an extensive understanding of a specific product or process type can perform the audit with an informed approach (Olson, 2011). Third party auditing providers prefer auditors with a broad knowledge base of different processes. When an auditor has breadth of knowledge, the audit provider is capable of servicing a broad spectrum of food processors (Androta & Pooja, 2009).

Corporate food safety professionals are needed to sustain food safety programs (Ollinger, 2011). Corporate level employees may have extensive experience in factory level operations. Experienced employees can assist quality assurance professionals' transition from a reactionary management approach into a system of assessment and corrective action. A systematic approach toward process improvement requires a collaborative relationship between quality auditors and food safety professionals (Stier, 2011b).

University extension programs capitalize on emerging improvement technologies that enable food-processing companies to sustain in the marketplace (Higgins, 2011). Industry specialists rely on university resources to conduct research projects aimed at investigating innovative techniques to increase productivity (Terreri, 2009). Implementing tested innovative procedures and processes is a partnership. Controlling the production process is mandatory for managing product quality (Stier, 2011a). Third party auditors' use verification procedures to ensure the ingredients purchased conform to established quality specifications (Johnson, 2011).

Third party audits are effective to identify food safety deficiencies in supplier's factories that could lead to food-borne illnesses (Albacete-Sáez, Fuentes-Fuentes, & Bojica, 2011). Food-processing companies become unaware of issues because of familiarity with the physical surroundings and procedures that could harbor potential hazards (Higgins, 2011). Managers face challenges to schedule time during the week to observe employee food safety and processes designed to inhibit food safety failures (Giacometti et al., 2012).

Creating opportunities to evaluate employee performance, issues that may hinder performance, equipment malfunction, and general quality related situations that may contribute to failures provide an important assessment tool for a manager (Hanacek, 2011). Employing the

use of third party and customer quality audits enabled companies to gain an awareness of process deficiencies. Third-party audits focus on processes that may contribute to food-borne illnesses (Albacete-Sáez et al., 2011). The quality assurance managers must manage the auditor and the agenda for a third party audit. The entire management staff is accountable for the results of the audit (Olson, 2011).

Food-processing companies must develop and implement procedures to address inherent food safety concerns within the process (Purdy, 2012). Validated work instructions to train employees on food safety principles are mandatory within certain third party audit plans. Food-processing companies must maintain records for two years on site if the auditor requests additional documentation (Stier, 2009). Preparing for an audit is not relegated to the quality assurance department. The entire management team may participate in the process to help ensure the staff is prepared for the audit (Stier, 2011b). Management leadership can conduct internal audits to ensure adherence to protocols, and initiate corrective and preventive actions (Albacete-Sáez et al., 2011).

Customer audits could prove essential in specific product use conditions (Stier, 2011a). Customer auditors can identify a process deviation that does not affect regulatory compliance; however, the deviation may have an economic effect on the customer's factory (Sedlock, 2007). Food processors experienced an increase in customer and third party quality audits of 325% from 1995 to 2000 (Stier, 2011b). Food industry groups initiated the Global Food Safety Initiative (GFSI) in 2000 to reduce the amount of food safety audits and the cost associated with redundant audit formats.

In 2008, Wal-Mart Stores Incorporated announced that suppliers of the food products sold in Wal-Mart retail stores are required comply with the certification process associated with GFSI by 2009 (Crandall et al., 2012). GFSI is an umbrella organization that authorizes a select number of auditing schemes considered compliant to the GFSI guidance document. The document is an extensive body of food safety management schemes focused on supplying safe food to consumers on a global scale.

Third party auditors provide a snapshot of the suppliers' operation. Processing companies need an in-depth understanding of the supplier's operation in relation to how a product performs in the customer's factory (Hernandez, 2010). An example of the scenario became evident in the Listeria contaminated cantaloupes incident in 2011, which infected 146 people in 26 states and resulted in 30 deaths (Weise, 2011). The melon producer employed a third party company to perform a baseline quality audit of the packing shed. Weise (2011) stated the auditor observed the operators of the packing shed used untreated well water to wash the produce. The use anti-microbial agent in the wash water is an FDA guideline, not a regulation (Liu, Ream, Joerger, Liu, & Wang, 2011).

The operators of the packing shed did not comply because a guideline is a recommendation and not enforced as a regulation. The production facility continued the practice and shipped product until the outbreak occurred (Weise, 2011). Social compliance provides a far greater effect than strictly adhering to government agencies' regulations. A company's ability to manufacture a product that exceeds the safety regulations and ensures the protection of the consumer is imperative (Berzau, 2011).

Proper procedures and programs to manage a system that uses internal quality auditors to reduce opportunities for food safety failures are imperative (Sperling, 2010). The creation of a process auditing team must comprise a cross functional representation of department employees. Choosing personnel directly involved with manufacturing and distribution of the product is imperative (Alhatmi, 2010). Creating multi-disciplinary teams enables individuals to perform a complete analysis of the inter-depend functions within the organization (Purdy, 2012). The team focuses on producing a safe and wholesome product for consumers (Fritz & Schiefer, 2009).

Quality assurance professionals are challenged to implement either a multi-faceted approach or a direct method quality-auditing program (Stier, 2011b). Both methods eliminate critical food safety failures originating from the supply chain (Rönnbäck, Witel, & Enquist, 2009). One opinion is that a cohesive supplier-auditing program is sufficient to provide a structure to deter quality incident. Place the auditor in a food-processing location and allow the professional to work is a consensus among a population of QAP (Perego & Kolk, 2012).

An opposing opinion is that quality system audits are incapable of determining the intrinsic contributing factors to critical food safety errors (Rönnbäck et al., 2009). A dilution of quality audit results can occur when the auditor evaluates complex processes in a limited amount of time (Albacete-Sáez et al., 2011). Developing a system to perform a targeted or narrowly focused quality audit could allow an auditor to engage in supplier improvement analysis (Bermudez & Schmidt, 2009). A comprehensive approach toward identifying potential risks based on previous incidents, and eliminating the threat before it comes to fruition, is the best method to address supplier improvement (Lee, Choi, Han, Woo, & Chun, 2012).

**Supplier Improvement Program**

Supplier improvement is a term referring to a program developed to reduce quality defects with a supply chain (Bermudez & Schmidt, 2009). Food-processing company managers rely on ingredient suppliers to provide safe, wholesome, and defective free products. The type of defect may initiate a specific response depending on the severity of the defect range from *minor* to *major* (Lee et al., 2012). Critical food safety failures classified as a major incident could create product recall scenarios. Issues classified as a minor issue normally cause minimal production disruptions (Turner, 2011). The evaluation of ingredients' physical characteristics provides the amount of defects in relation to foreign material, indigenous material, size, weight, color, and olfactory (Doherty, 2011).

The certificate of analysis (COA) reflects the test results of chemical characteristics of an ingredient. Using the COA as an important indicator of specification compliance determines the chemical attributes of the ingredient to ensure a consistent product (Fotopoulos et al., 2009).The COA is an internal regulatory tool to validate ingredient characteristics and wholesomeness (Aravindan & Maiti, 2012). The FPC uses the COA system to verify the supply chain is complying with internal specifications and regulatory agency requirements

Federal regulations require food-processing company managers to report all major incidents to the inspector on site (Aravindan & Maiti, 2012). The USDA and FDA agents review the facts of the incident and monitor the response of the food processor to ensure compliance to the regulations. Executive review boards review the responses of major incidents, which consist of regional directors within the respective regulatory agency (Chaudhuri, Mukhopadhyay, & Ghosh, 2011).

The role of the review board is to ensure the food processors are in compliance to the existing regulations and add to the strength of the proposed corrective actions (Chaudhuri et al., 2011). USDA recommendations and process requirements determine the microbiological specification for each ingredient (Wagner, 2012). The FPC suppliers send composite samples from ingredient manufacturing day codes to the FPC's microbiological testing laboratory. The samples are tested for prohibited pathogens known to induce illness. Prior to shipping the ingredient, suppliers are notified of the test results. Based on the result, the supplier either releases (negative) the ingredient for shipment or disposed of (positive) for noncompliance. Pre-screening of incoming ingredients from suppliers is a critical component of a food processors microbiological screening program (Wagner, 2012).

Food-processing companies must comply with existing USDA and FDA regulations, and meet the requirements of the consumer base (Andersen & Skjoett-Larsen, 2009). Maintaining social responsibility programs, not covered by regulations within the supply chain, is a challenge for suppliers and customers of ingredient suppliers (Boyle, 2009). A supply chain is only as strong as the individual components to deliver goods, services, and waste eliminating procedures (Aravindan & Maiti, 2012).

Manufacturing companies must develop supplier improvement programs with the goal of reviewing supplier's quality control points to prevent a food safety related defect (Henke & Zhang, 2010). If a food safety related defect is identified in a suppliers' ingredient a sequence of scripted events must take place to minimize the effect of the noncompliance. The ingredient is isolated immediately in a secure location at the factory. Employees perform a physical count of the remaining amount in storage to ensure the ingredient is captured and controlled. Quality

assurance employees enter the ingredient defect data into the VCD including the exact manufacturing day of the ingredient, referred to as a *lot code*.

Lot code information is important to the other FPC factories that may have received the similar ingredient and lot code. The ability to identify and isolate the suspect ingredient reduces the risk of expanding the food safety risk throughout the food-processing industry (Nga, Sigurdur, Sigurjon, Sveinn, & Thórólfur, 2010). The FPC practices performing traceability in a controlled situation to ensure the tracking and location system are operable when needed. Identifying and isolating defective products enables quality assurance managers to manage risk from potentially harmful products reaching consumers (Barrett & Rizza, 2009).

Eliminating defects and redundant procedures from the supply chain is the goal for companies focused on continual process improvement (Wu, Zhai, Zhang, & Xu, 2011). Food-processing companies need to establish a method to identify and eliminate redundancies, nonessential procedures and defect generating processes. The FPC evolved into an organization focused on educating employees in process improvement techniques and waste reduction. Employees must attend 50 hours each year of training designed to focus on production line improvements, safety awareness, six sigma principles, and quality improvement. Companies focused on waste reductions based on product quality improvements may increase market competitiveness and sustainability (Chaudhuri et al., 2011)

Establishing a partnership based on eliminating waste in the supply chain is a component of the three-year operating plan. Suppliers focused on streamlining processes and reducing operating costs are in a better position to absorb price reduction requests from customers (Kannan & Keah, 2007). The FPC developed monthly supplier quality meetings focused on

identifying suppliers that caused the highest volume of quality incidents. The use of a histogram or Pareto chart identified the suppliers that required the attention of the supplier improvement program (see Figure 2).

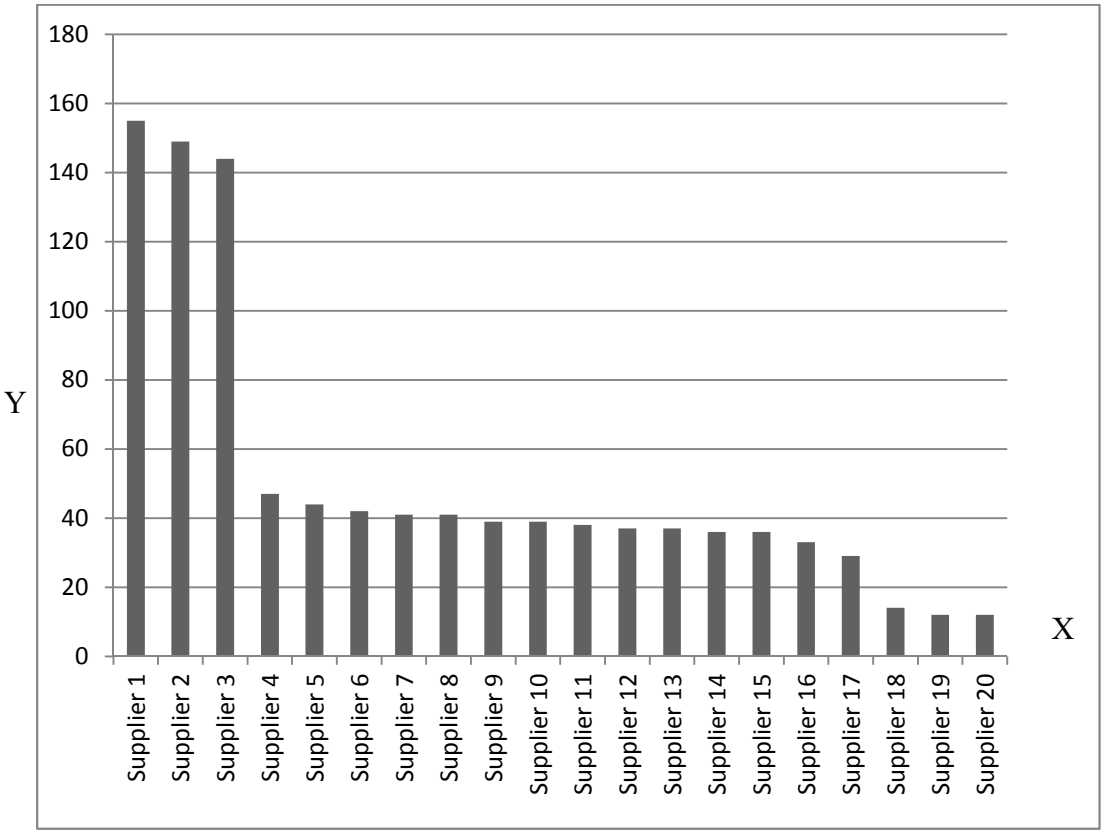


*Figure 2.* Supplier incident histogram. Professionals of the industry can use the chart as an example of supplier incident rates for a 1-year period. The Y-axis displays the incident rates, and the X-axis indicates the individual suppliers.

The QAPs of the FPC used a format referred to as the 80 – 20 rule. A description of the rule is 20% of the supplier account for 80% of the incidents. In Figure 1, 15% of the supply base accounts for approximately 60% of the total incidents. The QAPs of the FPC focused on the first three suppliers that recorded the highest levels of incidents. An extensive Pareto analysis performed by the QAPs using the histogram chart determined what type of incidents occurred at

the highest frequency. The detailed information regarding the incident type enabled the management of the supplier to focus improvement efforts in a concentrated area of the production process.

The use of a supplier scorecard program is an essential method to track, display, and encourage supplier improvement (Jarrar & Smith, 2011). A scorecard system is based on four criterion that evaluate product quality, compliance to documentation, compliance to product specification and financial effect on quality related noncompliance claims (Tse & Tan, 2011). The suppliers use the scorecard system to generate corrective actions to drive improvements in the system. Suppliers and the customer company employees enter the scorecard data into the contract evaluation program (Carbone, 2009).

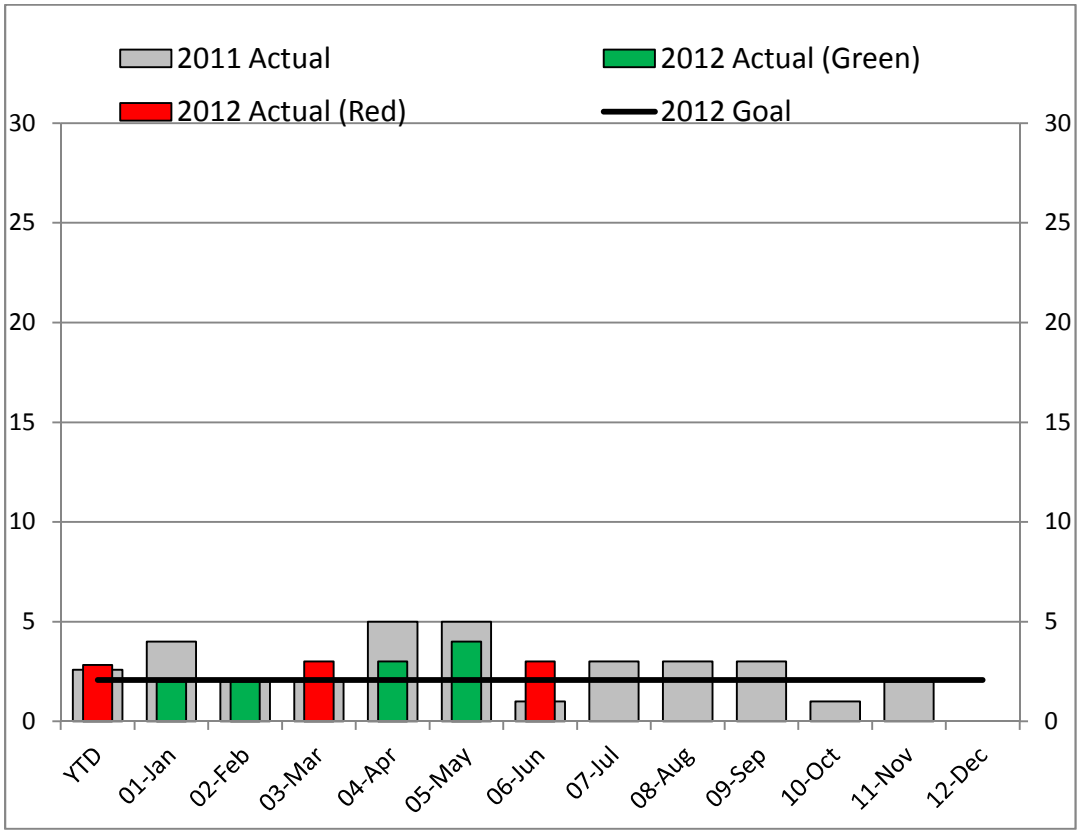

*Figure 3*. Scorecard example. Professionals can use the chart to display supplier incident rates on a monthly basis. Gray bars in scorecard reflect the supplier's record from 2011. The red bar signifies the 2012 monthly incident level was greater than or equal to the monthly incident level of 2011. The green bars indicate the 2012 monthly incident level is less than the 2011 level and is considered improvement by the management of the FPC. The target goal is displayed by the solid black line and indicates the monthly targets to achieve the annual performance goal.

The FPC uses the scorecard system (see Figure 2) to initiate supplier improvement procedures based on complaint data collected at the factories. Data is collated monthly and forwarded to the supplier. The individual supplier is responsible for identifying the source or root cause of the complaint. Suppliers are required to perform a *genba*, a Japanese term for physically walking the factory floor to see the problem. The practice of performing a genba enables the managers of the company to see the issue clearly and formulate corrective actions based on fact not opinion (Imai, 1997).

Once a root cause validation is complete, employees develop a corrective action or measure to address the root cause (Jarrar & Smith, 2011). The corrective action is compared to a metric to determine the effectiveness of the correction. The scorecard details the root cause, corrective action, and the result of the process improvement. Participants may conduct a meeting to address each issue and corresponding corrective action. A review process allows the participants to engage in further discussion regarding prevention of further incidents (Yaghoubi, 2011).

Developing an alternative approach to quality audits other than focusing on passing the audit is important (Davis, 2007). Companies request the audit format in advance and prepare for

each segment of the audit. A strategy that focuses on the basic components of the audit still may fail because of an oversight of food safety issues outside the scope of the audit (Fischer, 2007).

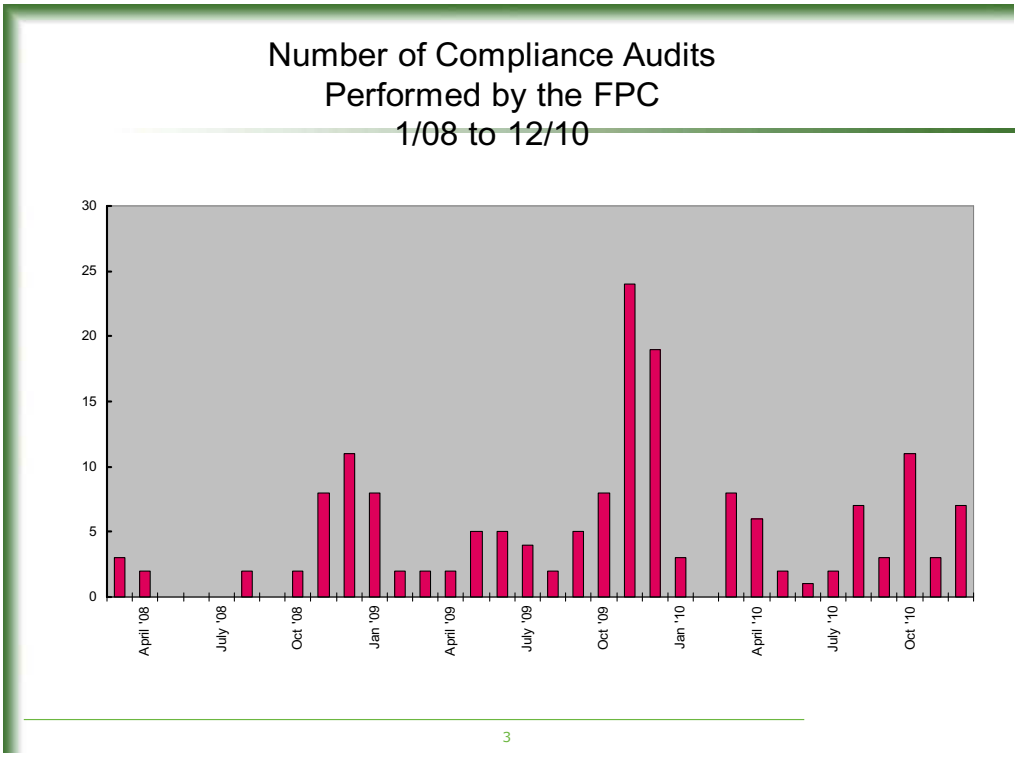


*Figure 4.* Compliance audits performed by the FPC 1/08 to 12/10. Professionals in the industry can use the histogram chart, which displays the amount of compliance audits performed by the FPC starting January 2008 to December 2010. The red bars represent the number of audits performed each month. The FPC to perform audits to ensure these suppliers is incompliance with regulations. The higher the bar indicates an increase in the frequency of compliance audits performed.

Compliance audits performed at supplier locations are required by the management of the FPC and regulatory agencies (see Figure 4). The audits are focused on specific programs considered critical to producing a wholesome ingredient that complies with the product specification. Pest control is an integral component of a food safety compliance audit. During the

documentation review portion of an audit, an auditor may verify the company is compliant with standard pest control requirements. Examples of the requirements are: proper amount of traps in and around the structure, validated pest control licensing, chemicals properly stored, and frequency of pest control inspections performed. If a live pest is in the factory during the observation portion of the audit, the company can fail the audit even though they met the requirements (Yeung, 2004).

The implementation of standardized operating procedures must ensure the process monitoring systems control quality variations. Producing a document to demonstrate how the process should work for the auditing group is a higher valued activity (Van Arnum, 2011). Food processors may benefit by developing a supplier quality manual (Yaghoubi, 2011). Ford Motor Company (FMC) developed the concept of a supplier quality manual. Suppliers to FMC received a manual containing detailed information regarding product specifications, packaging requirements, shipping standards, and generalized company information (Govindan, Kannan, & Haq, 2009). The pharmaceutical industry uses supplier manuals and is an integral component of a comprehensive approach toward supplier management (Van Arnum, 2011). An example of a supplier quality manual may contain the following: company vision statement, list of brands, pertinent ingredient specifications, receiving schedules, processing requirements, and contact lists. Maintaining a supplier quality manual in a digital format ensures flexibility in format and content changes (Yaghoubi, 2011).

The benefit of leveraging existing supplier's internal quality improvement plans lead to additional programs tailored to fit the needs of the customer (Aravindan & Maiti, 2012). External forces exert financial pressure on suppliers to drive change management and performance

directives. Food processors companies that own specific retail brands are compelled to implement additional food safety systems and procedures to protect the name. The term *brand equity* is associated with the financial value of consumer recognition of the brand. Managers of food-processing companies consider the brand name an asset and manage the risk associated with leveraging an asset (Bayo-Moriones et al., 2011).

In 2008, the FPC implemented a program called Interpretative Structural Modeling (ISM) to increase supply chain performance and reduce waste (Hussain & Drake, 2011). The developers of the ISM program focused on: evaluating and developing business relationships, managing competitive pressure, supplier incentives, supplier development programs, buyer-supplier relationship, buyer supplier communications, supplier performance, and buyer performance (Govindan et al., 2009). Developing suppliers' internal quality systems improves operational capabilities and performance. ISM explained the relationship among supplier development criteria and determined optimal drivers for supplier development (Hussain & Drake, 2011). Hussain and Drake also recommended a quantitative study based on structural equation modeling (SEM) for assessing the validity of the results as an additional step to the ISM study. Process improvement employees may use ISM to understand complex situations and construct corrective actions for solving problems (Sagheer, Yadav, & Deshmukh, 2009). Managers in the food processing industry choose the ISM model to understand critical elements influencing regulatory compliance, considering its capability to map complex relationships between industry and regulatory agencies (Sagheer et al., 2009).

Regulatory agencies encourage food processors to commit resource toward employee education (Barrett & Rizza, 2009). Food-processing companies have a need to challenge

themselves and suppliers to adopt procedures and programs focused on teaching employees food safety principles (Fuhrman, 2011). Employees who understand and practice safe food handling procedures may reduce food-borne illness potential contamination by 85% (Brunninge, 2009). Continual education of the production employees requires food-processing managers to provide the commitment and financial resources (Rodrigo et al., 2010). Food safety training specialists estimate an adequate amount of training is 10 -15 hours every six months for production employees (Fuhrman, 2011).

Food companies must become learning companies in regard to food safety (Chapman, MacLaurin, & Powell, 2011). A supplier improvement program focused on evolving with advances in screening devices (x-ray, laser color sorter, metal detection) is the next level of prevention. The FPC implemented an incentive program for suppliers to purchase screening technologies in the form of x-ray units and laser color sorters. Laser color sorters detect foreign material in vegetables and x-ray units detect bone fragments in poultry ingredients.

The FPC designated two poultry suppliers to test x-ray performance. Three x-ray manufacturers agreed to provide their x-ray units and technologists to set up and provide support during the trials. Validation procedures for each x-ray unit included the following: standardized poultry sample for the number of pieces (10,000), weight, size, and line speed (rate the piece travels through the x-ray). The test results were conclusive. All three manufacturers x-ray units' correctly detected bone in the test pieces at a 92% - 96% proficiency rate. The FPC abstained from designating which brand of x-ray product to purchase, only to purchase the technology, and screen all FPC products prior to shipment.

Vegetable suppliers for the FPC use optical color sorters to identify extraneous vegetable material (EVM) and foreign material (FM) contamination from frozen vegetables (Hussain & Drake, 2011). Supplier improvement professionals employed by the FPC perform trend analysis for supplier related quality incidents on a monthly basis, by ingredient type (meat, vegetable, cheese, minor ingredients). In September 2008, the supplier improvement managers identified an increase in VCD incidents specific to plastic contamination in broccoli.

The managers of the supplier improvement program for the FPC contacted the individual broccoli suppliers and scheduled on site factory assessment visits. The purpose of the on site assessment was to investigate the root cause of the contamination and help the supplier to perform a root cause analysis and construct corrective actions. The management team of the supplier implemented an immediate action plan to eliminate the source of the contamination. Root cause analysis and corrective actions are the foundation for process improvement (Collins, 2009)

A plan to address the issue was two-fold: implement procedures to reduce the potential for contamination and increase the detection capability of the sorters. The broccoli supplier used plastic bins to transport the harvested material from the field to the processing factory. The bins were similar in color to the broccoli. The plastic bin material matched the plastic contamination samples retrieved at the FPC factory.

A corrective action plan detailed the managed replacement of the existing bins to a color that contrasted the vegetables harvested and processed by the broccoli company. The management of the supplier implemented an inspection program to identify damaged bins and

immediately remove them from service. Employees working on the harvest crews require annual training to identify and prevent potential contamination incidents (Barrett & Rizza, 2009).

The broccoli supplier used color sorters to identify and eliminate EVM and FM. The limiting factor for the existing sorters was the inability of the sorter to discern between plant material and nonplant material if the color of the two substances were similar. The broccoli supplier contacted the existing laser sorter manufacturer to participate in the discussion related toward detection of plastic contamination. The laser sorter manufacturer presented an upgraded version of the existing sorters in place that featured additional sensors able to detect non chlorophyll (isolated to plant material) containing substances. The new technology enabled the sorter to *sniff* or detect through specific sensors the presence of chlorophyll and reject material that did not contain the substance (Fritz & Schiefer, 2009). The broccoli supplier initially leased a test model, validated the capability, and purchased 15 units in 2010.

Garcia (2012) argued that leadership is the driving force behind settling for compliance and achieving greatness. The FPC determined the use of incentives to purchase screening technology creates innovative thinking. Purchasing managers employed by the FPC, reward suppliers for re-investing into the process capability of the business. When leaders of corporations execute positive business management principles the companies they lead should succeed in the marketplace (Matyusz, Demeter, & Csenge, 2012).

## Transition and Summary

The purpose of Section 1 was to introduce the supply chain management of an FPC. After experiencing substantial success with reductions in microbiological incidents, the FPC experienced an increase in foreign material contaminations resulting in product recalls. The

suppliers' required further assistance in developing supplemental programs focused that reduce the risk of foreign material contamination. The FPC implemented a supplier improvement program that supplemented quality audits in 2010. Section 2 is a review of the details of the proposed project and the research methods.

## Section 2: The Project

Section 2 includes a discussion of the purpose statement, the role of the researcher, participants used in the research, and the research method. Additionally, Section 2 contains the data collection techniques and the data analysis tools. Included are explanations of the reliability and validity of the data to ensure the accuracy of the findings.

### Purpose Statement

The purpose of the quantitative, causal-comparative study was to examine whether a supplier improvement program implemented by an FPC had an effect on supplier-related quality incidents. The examination of variables in this study consisted of supplier-related food safety incidents (dependent variable) and a supplier improvement program (intervention).The population group of the study was a supplier base for an FPC in the United States.

The database consisted of 2,000 ingredient suppliers providing more than 15,000 items in a period from 2007 to 2012. The data points exceeded 25,000 incidents within the 6-year period. Researchers use data in the form of facts, observations, images, computer program results, recordings, and measurements; data may be numerical, descriptive, visual, or tactile (Simon, 2006). A supply chain that produces poor-quality products can cause business disruption, financial loss, costly lawsuits, and long-lasting damage to the brand and corporate image of organizations dependent on vendor performance. In the extreme, a brand, or the reputation of a company, can sustain damage from supplier quality incidents (Turner, 2011).

## Role of the Researcher

In the quantitative, causal-comparative research project, my role was to secure, organize, analyze, and interpret the data. The researcher must ensure that the sources of data used in a study are credible (Yu-Jia, 2012). An existing dataset provided by the FPC was the basis of the study. The data reflected the numeric frequency of supplier-related quality incidents and were entered by employees of the FPC. The database was managed and secured by the employees of the FPC.

I did not participate in the collection of the data. Employees of the FPC collected the data between January 1, 2007 and December 31, 2012. The data were organized into standardized datasets and entered into a statistical software application. Predictive Analytics Soft Ware (PASW) GradPack Base version 18—statistic analysis tool analyzed and displayed the data. The results of the data analysis provided discussion points regarding the interpretation of the data and recommendations for future research.

## Participants

The use of participants was not required for the study. The FPC granted permission to use data consisting of supplier-related quality incidents for a 6-year period (2007-2012; see Appendix A). Selecting a population large in scope is imperative to gain an understanding of the population one is studying (Simon, 2006). The dataset encompassed greater than 25,000 data points consisting of supplier incidents recorded by employees of the FPC. Names of the suppliers and the company that collected the data remained anonymous to comply with the conditions of the agreement. The supplier incident data and the names of the suppliers were confidential trade secrets, and the agreement stated that this confidential information would remain protected.

## Research Method and Design

The purpose of the study was to examine supplier incident data (dependent variable) before and after a supplier improvement program (intervention) to determine if the program affected or influenced the supplier incident data. The quantitative research method and causal-comparative design were the most appropriate design to examine if an ex post facto cause-and-effect relationship exists between two variables (Yu-Jia, 2012). The focus of this study was to examine one variable in two groups: supplier incident data (dependent variables) before and after a supplier improvement program (intervention). The research IRB approval number is 05-15-13-0165410.

### Method

The quantitative method provides numeric variables and relies on the analysis of numerical data (Tsai & Chiu-Feng, 2012). The quantitative causal-comparative study was based on an examination of numeric data to determine if a supplier improvement program changed the dependent variable (supplier quality incidents). The quantitative method enabled a determination of whether there was a significant difference in the dependent variable before and after the intervention (Yu-Jia, 2012). A qualitative methodology was not used because the qualitative method is a systematic subjective approach often used to describe human interactions and provide meaning (Weathers et al., 2011).

The focus of the study was on the frequency of supplier quality incidents in two distinct time-frames separated by the addition of a supplier improvement program. The data range of 2007-2009 represented the pre-supplier improvement program period, and the data range of 2010 to 2012 represented post-supplier improvement program period. The purpose of the study

aligned with the positivism worldview. The quantitative research method was the optimal method associated with the positivism worldview because the positivism system equates very closely with the traditional, scientific view of the world (Chaudhuri et al., 2012).

The three main features associated with quantitative research are objectivity, limited generalization, and numeric data (Meckstroth, 2012). The study included all three features and a causal-comparative research design to examine the independent and dependent variables. I concluded that the quantitative research method was the most applicable method to the study.

A mixed methods methodology applies the strength of quantitative and qualitative approaches used in social and human science research (Suddath, 2010). A researcher gains greater latitude to choose the type of data to analyze with a mixed method study (Weathers et al., 2011). I considered a mixed method approach; however, the data were numeric and derived from an existing database containing information on events. The study was focused on numeric results of a program and not the effect on the human participants working in the program. The mixed methods form of research requires a researcher to perform extensive data collection, and the process of analyzing text and numerical data is time intensive (Tsai & Chiu-Feng, 2012). I determined that a quantitative method of research was appropriate for the research project.

**Research Design**

The doctoral research study was a causal-comparative or non experimental research project founded on existing supplier complaint data. A causal-comparative study is referred to as an ex post facto study because both the effect and the alleged cause have already occurred and are studied in retrospect (Kaur, Singh, & Inderpreet, 2013). A hypothesis (or several hypotheses) guides experimental research and states an expected relationship between two or more variables.

To support or disconfirm an experimental hypothesis, a researcher must conduct an experiment through manipulation of environmental variables (Meckstroth, 2012). I did not manipulate the environmental variables or the suppliers involved in the data. The suppliers were not from a randomly selected database; therefore, a non experimental design complied with the objectives of the study.

A causal-comparative study is a study in which the researcher attempts to determine the cause, or reason, for preexisting differences in groups of individuals (Tsai & Chiu-Feng, 2012). A causal-comparative study attempts to identify cause–effect relationships, whereas a correlational study attempts to identify relationships. Causal-comparative and correlational research methods are similar in that both are nonexperimental methods. A causal-comparative study focuses on two or more groups (independent variables) and one dependent variable (measured for comparison), and a correlational study typically involves two (or more) variables and one group. I was not concerned with the human behavior aspect of supplier improvement in the study. The basis for the study was an analysis, interpretation, and conclusion of the numeric differences expressed in the frequency of supplier incidents increasing or decreasing after the intervention. A quantitative, causal-comparative study is an appropriate methodology to determine if a cause-and-effect relationship exists between variables (Cláudia et al., 2009).

## Population and Sampling

Individuals did not participate in the study. I used an existing dataset of quality defects associated to ingredient suppliers from 2007 to 2012. The FPC contracts with 2000 suppliers to provide ingredients to five processing factories. The suppliers in the dataset were large and small

capacity companies, publicly traded, and privately held, domestically sourced, and foreign owned businesses.

The sampling method was purposeful and quantitative. The data reflected supplier performance-based upon supplier quality incidents recorded by the FPC. A researcher must choose a population capable of providing an adequate sample size that generates rigorous data (Muskat, Blackman, & Muskat, 2012). The sample size of 2000 suppliers encapsulated the relevance of the study in relation to supplier improvement within a designated supply chain and the availability of the data.

The data generated by the FPC provided a cogent sampling of quantitative data because of the eclectic group of ingredient types and regions in which the products originated. At the time of data collection (2007-2012), the eligibility requirements for the participants sample were two-fold: an active supplier in good standing with the FPC and supplying a minimum of 50,000 pounds of ingredients within the 2007 to 2012 period. The criterion ensured a statistically significant sample size to determine the effects of the supplier improvement program. A robust sample size is imperative for a researcher to interpret the study results accurately (Meckstroth, 2012).

## Ethical Research

The study did not contain data from individual participants; therefore, consent forms, confidentiality agreements, and letters of cooperation did not apply to the study. The data pertaining to the study remained confidential for the FPC by not disclosing the name of the company or the suppliers. The FPC granted permission to use the database (see Appendix A). The management of the FPC controlled and managed the data. Only authorized personnel used

the information. The data remains in a secure off site digital storage location owned and managed by the FPC, until the information is deleted from the system after a 15-year period.

The obligation of researchers is to conduct studies with credibility and employ ethical methods throughout the research project (Wester, 2011). I am a Walden University doctoral student and required approval by the University's Institutional Review Board (IRB) prior to receiving and analyzing the data. The IRB mandates the research proposals meet the criteria of institutional regulations; professional conducts, and practices standards (Gearhart, 2010). The data collection stage is a crucial step in the research process, and researchers must respect vulnerable populations and avoid putting participants at risk. Procedures were implemented to anticipate and address each ethical dilemma that may have occurred at every stage of the project designed to prevent abuse. Researchers must adhere to ethical standards (Leedy & Ormrod, 2010).

## Data Collection

### Instruments

The FPC provides a realistic representation of the food industry because of the array and volume of ingredients purchased. The amount of data points collected on an annual basis exceeds 5,000. An examination of a five-year sample equates to approximately 25,000 data points. The FPC purchased a software system from System Application Products (SAP). The SAP software is the organizational instrument that secures the data points and stores them in a restricted access format.

The data collection instrument was a digital vendor complaint form accessible to authorized production and quality assurance employees. The employees of the FPC enter

supplier incident data when supplier related quality incident occurs. The quality incident data were stored and displayed in the VCD. The information technology (IT) employees of the FPC managed the database containing supplier related quality incidents. The employees of the FPC used the data to monitor and score supplier performance. The authorized employees in the five factories captured supplier-related quality incidents on receipt of the product or during the process. The management representatives of the FPC provided training for employees to identify ingredient related defects. The four main categories of defects identified by the FPC are physical, chemical, microbiological, and service.

Service related incidents included shipping document compliance, condition of the palletized product, and visual inspection the interior of the shipping container (Sams, 2011). The supplier is responsible for the condition of the shipping container and the product through the entire transit process. The supplier must maintain control of the shipping process to ensure the quality of the product to the customer (Stenner, 2009).

The supplier performance concepts measured are in relation to ingredient quality. Management of the supplier and the management of the FPC agree on a written specification for each ingredient. The ingredient specifications detail the chemical, physical, and microbiological attributes of the product. The individual data points reflected the frequency of supplier non-compliance. Three categories scored quality incidents (QI). A separate category in the VCD was service issues and was not applicable to the study because of the specific scope.

The tabulated scores represented each incident of supplier non-compliance and at the FPC raw material handling group. The group was responsible for sampling each day code of incoming ingredients and entering the correct data (identification number associated with the

ingredient, manufacture date, and the location). Sampling procedures performed by FPC employees identified ingredient deviations. The employees entered corresponding information into the VCD by supplier name, supplier factory location, ingredient type, day code, and incident type.

The calculated scores represented incidents, not a rate based on incidents per million pounds received at the FPC factories. The FPC utilized the data to evaluate supplier performance in the categories of service, and total quality. The total quality category consisted of the following three sub-categories: foreign material (wood, hair, metal, plastic), indigenous material (stems, seed pits, feathers), and specification compliance (analytical, chemical, microbial). Each data point represented an incident in one of the three subcategories found at the FPC factory.

In a quantitative study, two characteristics distinguish variables: temporal order and measurement (observation). The variables in the quantitative causal-comparative study may reflect a cause and effect order (Yu-Jia, 2012). Two sets of data when analyzed would determine if a relationship exists between the supplier improvement program and supplier related quality incidents. In the first dataset, the dependent variable came from the supplier management program in the 2007-2009 dataset and the implementation of the supplier improvement program in the 2010-2012 dataset. The dependent variables in both datasets were the amount of calculated supplier quality incidents, and formed the basis for the conclusion of the study. The controlled variable in both datasets was the amount of suppliers in the database.

The management of the FPC addressed threats to the validity of the data through proper training procedures. Pre-selected employees receive training in data entry procedures and must demonstrate competence in the procedures to gain authorization to enter data into the system.

The management of the FPC granted authorization to the operations employees to enter the supplier incidents into the VCD. Automated restrictions protect the information once the transaction is complete. Authorized Information Technologists (IT) employed by the FPC write the password-protected queries. A query program allows the user to filter data for specific characteristics to perform either trend analysis or provide detailed incident data to a specific supplier.

The Vice President of Quality Assurance for the FPC granted the use of the VCD data for research (see Appendix A). The legal name of the FPC was not referenced. The legal department of the FPC reviewed the document prior to publication. Once the research was complete, the FPC maintained final approval of the document prior to its release based upon the conformity to the agreement of content

**Data Collection Technique**

Each of the five FPC factories collected the supplier performance data. The quality assurance technicians performed AQL quality defect inspections on incoming raw materials. The certified production employees at the FPC factories collected the complaint data and recorded the data on a complaint data form. An FPC quality assurance employee entered the complaint data into the VCD. A common shared drive stored the data and was accessible to the supplier improvement team. The categories for the data were supplier name, type of defect, and frequency of the type of defect.

Contractors for the FPC designed the SAP-based data collection software. The capacity of the VCD was in excess of 18,000 data points and performed queries to manipulate the data into specific reports available to authorized employees of the FPC. The VCD was a component

of the SAP data management application and enabled the supplier management group to perform targeted evaluations of supplier performance. I did not to run a pilot program because the existing program managed by the FPC has worked for over 15 years.

**Data Organization Techniques**

The comparison consisted of five datasets of the annual supplier incident rates from 2007 to 2012. Six columns of data and dates were arranged in chronological order in a Statistical Program for Social Science (SPSS) PASW Statistics GradPack Base version 18.0. The number of supplier incidents appeared by year in ascending order. The data was stored and distributed in a shared drive protected by restricted authorization protocols. Only a trained employee, granted permission by his or her supervisor, can access the data. The design of the VCD software prohibited duplications, secured correct supplier names, identified the correct category, and tracked the database users.

## Data Analysis Technique

I did not use a survey to collect data in this quantitative, causal-comparative study. The expost-facto dataset consisted of supplier related quality incidents from 2007 to 2012. In January 2010, the FPC incorporated a supplier improvement program (intervention). I used the data years from 2007 to 2009 that represent the pre-intervention years and 2010 to 2012 for the post-intervention years (dependent variables).

The PASW Statistics GradPack Base version 18.0 is among the most widely used programs for statistical analysis in social and human behavior science (Yu-Jia, 2012). The particular software application enabled me to examine if a cause and effect relationship exists between the supplier incident rates of the pre-intervention years of 2007–2009 (DV), to the

supplier incident rates of the post-intervention years of 2010-2012 (DV) after the addition of a supplier improvement program. The PASW statistical software offers a variety of tools to analyze data. The statistical analysis tool proposed for the study is the paired *t*-test. A paired *t*-test is used to compare two population means in two samples. Observations in one sample are paired with observations in the other sample (Belli, 2008). An example of where this might occur is before-and-after observations on the same subjects.

The specific relevance of the hypotheses provides the question: What effect, if any, did a supplier improvement program have on supplier related defects for an FPC? The data may reflect trends in a direction that validates either the quantitative hypothesis or the null hypothesis. The basis for theoretical framework of the study is supplier process improvement. The employees of the FPC use measures to ensure a wholesome finished product that meets the specifications set by the FPC and consumer demands. The employees of the FPC implemented a verifiable supplier improvement program that focused on eliminating defects and inefficiencies out of the supply chain. The data captured by the FPC is a verifiable method to deduce if the supplier improvement program is creating an effective means to reduce supplier related quality incidents.

## Reliability and Validity

### Reliability

The reliability of a measurement refers to the consistency or repeatability of the measurement of some phenomena (Simon, 2006). If a measurement instrument is reliable, that means the instrument can measure the same thing more than once or using more than one method and yield the same result. A reliable instrument represents the true scores of the items assessed on specific dimensions, which improve and strengthen a study (Leedy & Ormrod, 2010).

Reliability refers to the consistency of assessment scores and is concerned with the accuracy, consistency, stability, and repeatability of a measure. An accurate representation is the true score of a variable on a particular level or dimension (Simon, 2006).

The reliability of the proposed dataset provided by the FPC is reliable because the same set of criterion to evaluate supplier performance was used during the six-year period of data collection (2007-2012). The ingredient-receiving employees for the FPC are restricted from altering the ingredient selection criterion of software application. Information Technology (IT) employees for the FPC monitor ingredient receiving software applications to validate data collection accuracy. In a business environment, maintaining a separation between employees who enter the data and the employees who verify the data is imperative for integrity in reporting the data (Leedy & Ormrod, 2010).

The FPC employees who collect the data do not work in the quality management department, which validate the data. Data protection protocols written into the application software create data reliability by preventing redundancies, which strengthens data entry accuracy. The IT department employees of the FPC are the only employees granted access to write or modify data protection protocols.

**Validity**

Two types of validity are in research: internal and external. The principle threat to the validity of the study is if the measurement system fails to achieve the purpose for which it was designed (Simon, 2006). To counter the principle threat, a researcher should show that repeated measurements with the same measurement instrument, under consistent conditions, would yield the same result (Trochim, 2006). The dataset used consists of supplier incident data collected by

the employees of the FPC that used the same criterion, data collection instruments, data recording software application, and supplier base throughout the 6-year data collection period.

Internal validity is relevant for studies that address cause-effect, causal relationships (Prowse & Camfield, 2013). The proposed study is a causal-comparative because it is important that I kept the focus limited to a numeric changes in the dependent variables (supplier incidents 2007-2009 and 2010-2012). After the analysis of the data, the basis of the conclusion is whether a significant change occurred in the dependent variable data. Determining the cause of the effect is limited to a specific intervention referred to as a supplier improvement program.

Conclusions drawn from a study that focus on a specific population, and subsequently transferred to a larger group, situation, or timeframe is a threat to external validity (Simon, 2006). I did not generalize the conclusions of the data analysis to a larger population (non-food product manufacturers) because the conclusions based on the research are specific to the food processing industry. Specific ingredient requirements are proprietary to individual companies; however, the expectation that ingredients should perform is common from one company to another (Andotra & Pooja, 2009). Extenuating variables do exist in non-food product manufacturing and are outside the parameters of the study.

## Transition and Summary

The information in Section 2 described the role of the ethical researcher, data collection methods, the design analysis to ensure reliability, and validity of the results. Section 3 includes a demonstration of the effectiveness of the data collection methods by the quality of the data collected and analysis of the data. The potential financial impact of the research may determine

the effectiveness of a program focused on reducing critical quality failures and the course of action for the FPC.

Section 3: Application to Professional Practice and Implications for Change

The purpose of the quantitative, causal-comparative study was to examine the influence of supplier improvement program on supplier-related food safety incidents. I sought to determine if a cause-and-effect relationship existed between an intervention (supplier quality improvement program) and a dependent variable (postintervention measure). Section 3 contains a detailed description of the results of the study, a presentation of the findings, the application of the findings in professional practice, and the implications for social change. A recommendation for action and future research and a reflection on the research topic are included.

## Overview of Study

The focus of this quantitative, causal-comparative study was an examination of supplier incident data within a 6-year period to determine if a relationship existed between a supplier improvement program and supplier-related incidents. The research question of the study was whether a supplier improvement program (intervention) affected or influenced supplier incident data (dependent variable) for an FPC operating in the United States of America. A paired *t* test analysis was conducted comparing two 36-month time periods of data. The supplier incident data were categorized by year and individual month. The first dataset represented the supplier incident rates prior to the intervention (2007–2009), and the second dataset represented the postintervention period (2010–2012). The hypotheses were as follows:

$H_o$: There is no statistical difference on supplier incidents with a supplier improvement program.

$H_1$: There is a statistical difference on supplier incidents with a supplier improvement program.

Based on the study results, the null hypothesis was found to be false and was rejected.

## Presentation of the Findings

Table 1 depicts the supplier incident data for 2007–2012 provided by the FPC. The data are displayed by months in rows and years in columns. The numbers in the corresponding cells represent supplier quality incidents recorded by employees of the FPC.

Table 1

*Supplier Incident Data 2007–2012*

| Month | Years | | | | | |
|---|---|---|---|---|---|---|
| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
| January | 344 | 395 | 388 | 417 | 302 | 244 |
| February | 345 | 402 | 401 | 411 | 289 | 223 |
| March | 389 | 441 | 422 | 395 | 281 | 225 |
| April | 355 | 405 | 432 | 375 | 275 | 220 |
| May | 365 | 411 | 452 | 370 | 277 | 219 |
| June | 344 | 399 | 444 | 382 | 285 | 216 |
| July | 346 | 378 | 411 | 385 | 265 | 222 |
| August | 389 | 416 | 402 | 362 | 275 | 217 |
| September | 344 | 411 | 445 | 367 | 253 | 211 |
| October | 369 | 402 | 427 | 344 | 244 | 208 |
| November | 374 | 411 | 486 | 325 | 241 | 211 |
| December | 389 | 399 | 422 | 311 | 240 | 201 |

Table 2 displays the results for a paired-samples *t* test that was conducted to evaluate the effect of the intervention on supplier incidents. The assumptions of normality and equal variances were assessed and met. There was a statistically significant decrease, $t(35) = 6.928$, $p < .01$, in postintervention incidents ($M = 285.86$, $SD = 67.75$) from preintervention incidents ($M = 398.75$, $SD = 33.99$). The mean decrease in incidents was 112.89 with a 95% confidence interval ranging from 79.81 to 145.97. The eta squared statistic ($\eta^2$) = .578 indicates a medium to large effect size (see Table 6).

Table 2

*Paired Samples Statistics*

| | Mean | *N* | *SD* |
|---|---|---|---|
| Supplier Incidents 2007-2009 | 398.75 | 36 | 33.99 |
| Supplier Incidents 2010 – 2012 | 285.86 | 36 | 67.75 |

Table 3 displays the results of the Kolmolgorov-Smirnov (K-S) test, $D(36) = .075$, $p > .05$, was normal. Because the K-S test may generate results that indicate significant normality in a large sample size, a histogram (Figure 5) was created to verify the results of the K-S test. Additionally, a skewness and kurtosis test was performed.

Table 3

*Test of Normality*

| | Kolmogorov-Smirnov[a] | | |
|---|---|---|---|
| | Statistic | *df* | *Sig.* |
| Difference[b] | .139 | 36 | .075 |

[a]Lillefors significance correction. [b]Calculated difference in scores between supplier incidents 2007–2009 and supplier incidents 2010–2012.

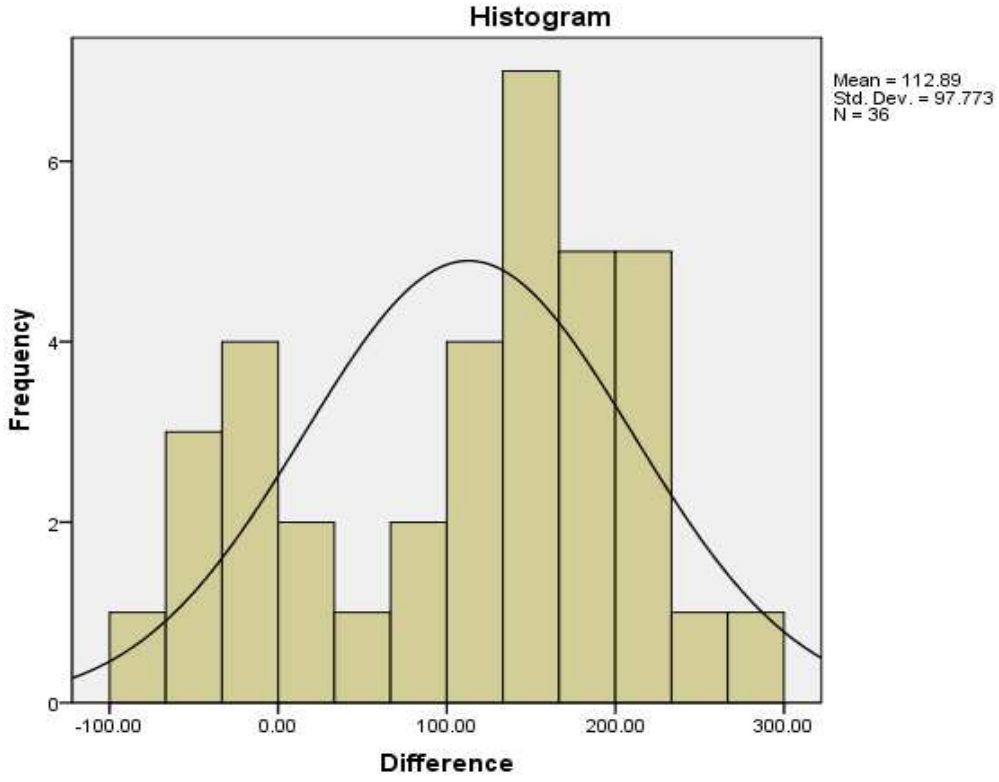


*Figure 5*. Histogram of the normality of the data. The histogram reflects the distribution of the difference in scores for the preintervention and postintervention data. The values displayed in the histogram show that 68.26% of the data points are within the first *SD* range of 15.12 to 210.66. The second *SD* entails 95.44% of the data points ranging from -82.66 to 308.43.

Table 4 displays the data associated with the analysis of skewness and kurtosis. The analysis of the difference between the pre-intervention and postintervention scores generated a numeric validation of the normality of the data. The skewness value of -.451 is within the range of -.786 to .786, and the kurtosis value of -.959 is within the range of -1.54 to 1.54.

Table 4

*Skewness and Kurtosis*

| Measurement | Value |
|---|---|
| *N* Valid | 36 |
| Missing | 0 |
| Skewness | -.451 |
| Std. Error of Skewness | .393 |
| Kurtosis | -.959 |
| Std. Error of Kurtosis | .768 |

Table 5 shows the Pearson correlation between the preintervention and postintervention conditions. The correlation is = -.828. A negative correlation indicates an inverse relationship between the variables. Within the 36-month interval, the number of supplier quality incidents increased for the preintervention dataset. The number of supplier incidents decreased in the 36-month postintervention dataset. A significance of .000 depicts a large enough difference between the two means to posit that the results are not by chance or random.

Table 5

*Paired Samples Correlation*

| | *N* | *r* | *p* |
|---|---|---|---|
| Supplier Incidents | 36 | -.828 | .000 |

Table 6 displays the eta squared statistic ($\eta^2$) = .578, indicating a medium to large effect size. The *df* was used to calculate the probability that a value of $t = 6.928$ could occur if the null hypothesis were true (There is no effect on supplier incidents with a supplier improvement

program). The probability of the null hypothesis being true is: *p* (2-Tailed) = .000. The 2-Tailed probability is appropriate for this test because there was not a prediction about the direction of group differences (type of suppliers, product differences, skills sets of employees at each supplier location).

Table 6

*Paired Sample Test*

| | ($\eta^2$) | *t* | *df* | *p* (2-Tailed) |
|---|---|---|---|---|
| Supplier Incidents | .578 | 6.928 | 35 | .000 |

**Findings Related to the Literature**

A strong relationship between proactive programs (supplier improvement) and supplier performance (supplier incidents) has been reported in the literature. For example, a study by Bandyopadhyay and Jenicke (2008) identified a strong correlation between proactive programs and supplier incidents in the automotive industry. Car manufacturers rely on their suppliers to provide parts that meet predetermined specifications to ensure the finished product meets the expectations of the consumer. Managers in the car manufacturing industry understood the importance of working with their suppliers in a proactive manner to ensure a consistent supply of defect free parts.

Another study by Van Arnum (2011) corroborated these findings as a relationship was found between using a multifaceted approach in supplier management and increasing supplier performance in the pharmaceutical industry. Using preventative measures to address supplier related issues is a challenge for the pharmaceutical industry. Programs ranging from supplier quality workshops, incident scorecards and supplier quality audits offer a proactive approach to

ensure a consistent supply of ingredients. Implementing a quality-auditing program to identify, report, and require supplier deficiencies is a valued component of supplier management.

Developing and sustaining a supplier improvement program is a directive for food processing companies in the Food Safety Modernization Act (FSMA). The bill was enacted by Congress in December 2010. FSMA is the most comprehensive, proactive food safety legislation since 1937. The law changed regulatory structures designed to protect the public from foodborne illness. The FSMA updates the FDA authority to regulate foods and food manufactures in a preventative manner. Prior to FSMA, the FDA only acted after a foodborne illness outbreak occurred. The FSMA enables FDA to design measures that prevent foodborne outbreaks from occurring, proactively regulating the food industry.

**Findings Tied to Theoretical Framework**

The theoretical framework for the study was the Toyota Motor Company's (TMC) supply chain management model. The focus of the model is improving the quality of incoming products provided by the supply chain. Sakichi Toyoda's concept of quality focused on the individual parts that make up the finished product. The ability for a food processor to secure a supply chain that provides wholesome products in an uninterrupted managed process will determine the sustainability of the company. The management of the FPC relies on the quality of the ingredients and packaging materials received to ensure a wholesome product.

The strength of the supply chain is a critical pillar in the general sustainability of a business. Implementing preventive measures to reduce or eliminate supplier generated quality issues creates an immediate effect on the final quality of the product. The management of the

FPC implemented a proactive supplier improvement program and realized a significant reduction in supplier incidents within the timeframe of 2010 to 2012.

**Findings Confirmed Literature on Business Practices**

The results are consistent with the literature review on business practices. The case of PCA's salmonella contaminated peanuts entering into the supply chain is an example of a failed supplier management program. The FPC's supplier management program auditing group dispatched an quality assurance professional to perform an audit of PCA's facility in 2009.The facility was rejected by the quality professional and the contracts for future product purchases were terminated.

The FPC understood the importance of monitoring supplier processes for food safety improvement to ensure the procedures exceed regulations established by the FDA and USDA. Failure to monitor supplier performance leads to critical failures and eventual consumer demands on federal agencies to implement additional regulations. The quality assurance professional for the FPC rejected the PCA facility responsible for the salmonella contamination, subsequently preventing the regulatory and legal ramifications of the recall affecting the FPC.

## Applications to Professional Practice

Two applications drawn from the conclusions of the research may apply to the general food industry. The first application is in regard to the ingredients utilized to produce a finished product. Developing and maintaining a supplier base capable of ensuring a consistent array of ingredients is a strategic market advantage. Food processors require a safe and stable supply of ingredients to ensure a wholesome product for consumers to purchase. An integral component of a supplier improvement program is the use of a quality incident database. The purpose of a

database is to identify suppliers not performing to pre-determined standards. Collecting poor quality incident data is a method to measure supplier performance and increase quality awareness.

The second application from the study pertinent to the food-processing industry is eliminating waste generated from supplier ingredients defects. When an ingredient is identified as defective at receipt, the ingredient is excluded from production because of quality deficiencies. The schedule is changed to accommodate the excluded product, and efforts are initiated to replace the defective product. Supplier quality incidents cause downtime for the production line and throughout the supply chain.

If a defect is identified during production the process is halted. The effected product is removed from the production line, and isolated. Depending on the type of quality issue, the production line may require cleaning and sanitizing prior to re-starting the process. Multiple steps are taken directed at correcting the issues associated with the defect. Steps that do not produce or support production of saleable product are considered waste (Boyle, 2009).

Sourcing wholesome ingredients that meet the specifications to produce a finished product consistent in quality is a critical component of an ensured supply program. Incoming goods specialists, for the FPC, are trained to reject ingredients that do not meet the pre-determined specifications. If the management of a food processing company cannot source a consistent supply of wholesome ingredients that meet predetermined specifications the effect is two-fold. The first effect is not achieving order fulfillment because the ingredients were rejected at the receiving dock of the food-processor. When the food-processor does not complete the order to the retailer a condition referred to as *stock out* occurs. A stockout is where a routinely

available product is not available and the retailer is unable to meet the consumer's demands (Turk, 2012). The consumer is forced to purchase an alternative branded product, thus causing a potential loss in customer loyalty. When the consumer is denied access to the brand they desire, they will turn to an alternative and cease to look for that brand (Yeung, 2001).

The second effect is when an ingredient is identified as out of specification, and is subsequently used to manufacture a product. The quality of the product is diminished and consumer's expectations are not satisfied. Continued practice in this manner can lead to the consumer not purchasing the product and reducing the financial strength of the company. Loss of business may cause a company to reduce employee numbers to diminish direct and indirect labor costs (Boyle, 2009).

## Implications for Social Change

The implications for positive social change include providing food-processing companies, supply chain managers, consumer advocacy groups, and consumers an additional method to reduce and avoid food-borne illness. Strengthening the supply chain of a food-processing company to ensure a reliable source of safe ingredients is an ethical and sustainable business practice. Supply chain managers may use the results of the study to argue the beneficial implications of developing and implementing a supplier improvement program. Consumer protection organizations search for methods to ensure safe food practices. The research results indicated a significant reduction in supplier incidents post intervention. Consumer advocate groups may refer to the results of the research when addressing regulatory agencies' request for public recommendations for regulatory guidance. Individual consumers may gain a platform to build trust in a brand or company that provides consistent quality and wholesome products.

Food-processing companies must achieve a baseline of consistent consumer safety, profitability, resource sustainability, and employee safety to stay competitive in the marketplace (Burns & Fogarty, 2010). If a food-processing company is continually experiencing food safety related issues deriving from the supply chain, the focus of the operation may become reactionary as opposed to prevention oriented (Burns & Fogarty, 2010). The management of the FPC examined the importance of transitioning from reacting to critical failures within the supply chain to a preventative approach. Complying with the preventative approach, the management of the FPC implemented a supplier quality-auditing program and a supplier improvement program.

## Recommendations for Action

The data analysis showed a significant reduction in supplier incidents after the implementation of a supplier improvement program. The use of a targeted approach appeared to reduce supplier incident rates. Using a targeted approach toward isolating specific quality attributes of supplier ingredients received at the factory level proved effective. Constructing and implementing a comprehensive approach toward identifying root cause, constructing actions plans, and performing validation audits drove the reductions.

Global supply chain managers and quality assurance professionals would benefit greatly from this research to aid in the formulation and implementation of an encompassing approach to ensuring the products their companies purchase are wholesome and safe. The researcher provided a literature review of one hundred peer reviewed articles and research documents to validate the concern for food safety in a variety of industries ranging from automotive to pharmaceutical. The desire for manufacturing to qualify an assured supply base is critical in a

global marketplace. Conducting supplier quality seminars, creating digital newsletters, writing articles for industry publications are examples of methods to disseminate the results of the study.

## Recommendations for Further Study

A recommendation for further study may contain the use of a repeated measures study. More than two measures may have beneficial implications to assess the longevity of an intervention. A limitation of the study was the amount of data confined to one food processing company. Quality assurance professionals may conduct a study examining multiple datasets generated from a larger and diverse population that should provide an expanded view of the efficacy of a supplier improvement program.

The population used in the research was ingredient suppliers of the FPC. Further study of packaging suppliers may achieve the same results and have a greater impact because of the considerable increase in volume of received product in comparison to ingredients. The FPC is a multi-billion dollar concern with greater resources to invest in supply chain quality. Further research into the potential opportunity to establish shared resources for smaller companies to utilize best practices created by larger companies, would benefit the food industry on a larger scale. The ability to leverage existing supply chain quality programs would increase product quality and consumer safety. Small to mid-size companies can contribute to the further study of supply chain quality management by attending seminars and participating in food safety discussion panels.

## Reflections

As an advocate and professional dedicated to supply chain quality, I did not believe the data would have shown the immediate positive effect on factory level vendor complaints, after

only a one-year period. The addition of a supplier improvement focused program, on an existing supplier management program, performed as a catalyst to expedite the process. A targeted approach toward isolating incidents, using root cause analysis, creating actions plans, and performing follow-up validation audits at the supplier locations created an accelerated improvement process.

## Summary and Study Conclusions

Food safety is not a proprietary concept. The vice president of quality assurance for FPC granted permission to use data collected by the employees for this research project. The vice president understood the importance of sharing information for the greater good. Food processors must focus on what will benefit the consumer base in total, not just a segment in which a company is focused on.

The data analysis provided results that confirmed what my previous thoughts were on the subject of supplier improvement. The first step of supplier improvement is to develop a program that identifies the suppliers causing the higher percentage of incidents and work with the management team to determine the root cause of the incidents. Identifying incidents and holding the management of the supplier accountable for corrective actions created focus on the root cause of the issues. My surprise was the significance of the reduction of incidents within a relatively short time. When quality incidents decline, fewer disruptions occur within the supply chain, and efficiencies for both the supplier and the customer can increase.

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# Appendix A: Data Use Agreement

[redacted]

**SENT VIA UPS**

September 30, 2011

Dr. Arthur Tyler
Walden University
155 5th Avenue
Minneapolis, MN 55401

Dear Dr. Tyler:

John Raede is employed by [redacted] as a Global Supply Chain Quality Manager. We understand that Mr. Raede will be analyzing reports from [redacted] Vendor Incident Database and utilizing data from 2007 through 2011 ("Data") to support his dissertation.

This letter is offering assurances to Walden University and the International Review Board that 1) the Data utilized by Mr. Raede is real and accurate; and 2) Mr. Raede has [redacted] permission to utilize and present the Data, provided however that, Mr. Raede has been instructed that the Data must be presented anonymously, i.e. in such a way that [redacted] is not identified by name or by specific description (e.g. [redacted]. In addition, neither supplier names nor business partners shall be identified by type of product reference and/or geographical location.

This Data is the trade secret or confidential information of [redacted] and is of great value to our company, as it is integral to the competitiveness of [redacted] in the marketplace. Mr. Raede has been reminded that while he is free to share his general knowledge, skill and experience outside the [redacted] he has a continuing obligation not to disclose or use any trade secret or confidential information of [redacted] organization, other than the Data as outlined above.

In his efforts to support his dissertation, we request your cooperation to avoid any conflict involving the disclosure or use of trade secret or confidential information of [redacted]

Sincerely,

[redacted]

Curriculum Vitae

**Doctorate in Business Administration: Walden University. October 2013**

**Master of Arts in Organizational Management: University of Phoenix. July 2002.**

**Bachelor of Science in Animal Science: California Polytechnic State University at San Luis Obispo. Spring 1990**

**Global Supply Chain Quality Manager** (2003- present)
Created Global Supply Chain Quality Improvement Program encompassing 1087 ingredient and packaging suppliers.
Collaborate with Supply Chain, Purchasing, Product Development, and Operations to prevent system failures resulting in Product Recalls.
Develop and implement extensive supplier certification and process improvement program focused on HACCP, GFSI certification, ISO22000, LEAN Supply Chain, Total Performance Manufacturing, supplier incident reduction and consumer safety.
Created a system to measure financial impact of vendor related incidents in relation to Cost of Non-Compliance.
Developed and implemented Supplier Quality Colleges to increase collaboration within Supply Chain.
Perform supplier incident investigations in North, Central, South America, and China to develop sustainable process improvement methods to eliminate waste in the supply chain.
Implemented process improvement teams at vendor locations to conduct process audits.

**Quality Assurance/ Vendor Quality Manager** (98-2003)
Developed Supplier Improvement program in collaboration with Purchasing/R&D/Operations.
Initiated a program to address lead shot contamination at the vendor level, and delivered the presentation at the 2002 National Cattlemen's Association Convention in Denver CO. The presentation focused on the financial impact on the retail processors using beef products contaminated with lead shot.
Developed a Supplier Performance Award program to recognize supplier quality achievements based upon Six Sigma continuous improvement principles.

**Raede & Associates: Principal** (97-98)
Developed a Foreign Contamination Control and Process Improvement program.
Performed Audits throughout the continental United States as well South America using a five-category approach targeting specific processes and procedures associated with clients products. It is my belief that a congruent path towards producing desired products is achieved through proactive evaluation, rather than punitive inspection.
Accountable for audits that focus on process controls, which inhibit and address potential pathogenic contamination.
Implemented TQM philosophies to client's vendors to minimize contaminated product.
Advised and implement GMP/HACCP programs for vendors when prescribed by clients. Conducted Vendor Certification for Chef America using criteria congruent with certification profile.
Performed GMP, HACCP, SPC, and problem solving training.

**Division Training Manager** (95-97)
Developed Process Improvement program involving 135 employees in three separate facilities. Process teams met for fifteen minutes prior to scheduled production runs to discuss specifications and proactive measures to reduce waste and increase labor efficiencies.
Implemented Safe Food Handling program for line workers that focused on education of bacterial growth temperature ranges, and the different types of harmful pathogens that cause food borne illnesses.

**Production Supervisor.** (93-95)
Initiated and established Process Improvement Work Teams.
Realized over $225,000 actual cost savings in process improvements in first 6 months of team deployment.
Managed 2-shift operation consisting of 83 mainly non-English speaking production employees, and 4 supervisors.
Increased Packaging Yields 27% within first eight months.

**Production Supervisor** (90-92)
Managed boning line crew of 63 employees.
Increased overall boning line yields 14% in first 3 months.
Increased 'cut specific" yields 28% above average.
Increased Labor Efficiency rates to average 102%.

**Rock Creek Pack Station: Head Packer/Trail Guide** (85-90 Seasonal)
Guided Pack Mule fishing/hunting trips through Golden Trout Wilderness, John Muir Wilderness, Kings Canyon National Park, and Yosemite National Park.

**Porterfield Ranch: Ranch Hand** (84-85)
Managed daily operations for 15,000 acre 300 head commercial cow-calf operation.