ASSESSMENT AND VALIDATION OF ON-PACKAGE HANDLING AND COOKING INSTRUCTIONS FOR RAW, BREADED POULTRY PRODUCTS TO PROMOTE CONSUMER PRACTICES THAT REDUCE THE RISK OF FOODBORNE ILLNESS

by

SARAH ELIZABETH DEDONDER

B.S., Emporia State University, 2004
M.S., Kansas State University, 2006

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Diagnostic Medicine/Pathobiology
College of Veterinary Medicine

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2012

Abstract

Not-ready-to-eat entrées purchased at retail and prepared in the home have been identified as a risk factor for salmonellosis. From 1998 to 2010, ten outbreaks implicated undercooked not-ready-to-eat entrées. In each outbreak, affected individuals prepared entrées in a microwave oven, did not follow recommended cooking instructions, and failed to take the internal temperature of the cooked product. This dissertation surveyed grocery stores for product availability, evaluated consumers' preparation practices of raw, breaded, frozen chicken entrées, and validated on-package label instructions. The survey of retail revealed that several manufacturers fail to provide consumers clear preparation instructions. A video capture system was used to observe food preparation practices of 41 consumers–21 primary meal preparers and 20 adolescents–in a mock domestic kitchen using uncooked, frozen, breaded chicken products, and determined if differences exist between consumers' reported safe food handling practices and actual food handling behavior as prescribed on product labels. Differences between self-report and observed food safety behaviors were identified between groups. Many participants reported owning a food thermometer (73 percent) and reported using one when cooking raw, breaded chicken entrées (19.5 percent); however, only five participants (12.2 percent) were observed measuring the final internal temperature with a food thermometer despite instructions on the product packaging to do so. Food handling

errors identified during the meal preparation sessions were then mimicked in a controlled laboratory setting to determine the impact of such deviations on end-product temperature. For all products, highly variable internal temperatures were recorded across entrées when prepared in a 600W microwave oven. Microwave cooking of raw breaded poultry products is unpredictable in achieving uniform target end-point temperatures; however, a 1000W microwave oven consistently produced a safe end product. Data collected through direct observation more accurately reflected consumer food handling behaviors than data collected through self-reported surveys. Low wattage microwave ovens failed to produce a safe end product. Processors should validate instructions for not-ready-eat entrées using a range of microwave ovens rather than a single wattage, develop a unique set of instructions for entrées, and provide consumers clear cooking instructions that result in a safe end product.

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Dr. Randall Phebus

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Acknowledgements

I would like to thank my major professors, Dr. Douglas Powell and Dr. Randall Phebus for their constant guidance, encouragement, and patience as I completed my dissertation. I would also like to thank my committee members, Dr. Justin Kastner and Dr. Abbey Nutsch for their feedback. To the Diagnostic Medicine/Pathobiology Department, thank you for providing me the opportunity to pursue my PhD.

A special thanks to Brae Surgeoner, Casey Wilson and Ben Chapman for their help with the observational study. To Danielle Perkin, thank you for your assistance in cooking frozen breaded chicken entrées for hours at a time. The cooking study would not have been completed without you, skittles, or sunflower seeds. Finally, thank you to Dr. Leigh Murray and Carlie Shannon for your guidance in analyzing the data. I will be forever grateful for your help throughout this process.

Finally, I would like to thank my husband, Keith and my two boys, Kerrick and Kason for their constant love and support during this process. I also want to thank my mother who gave up her Saturday mornings to watch my boys so I could work on my dissertation. To the rest of my family, thank you for your endless support despite the duration of the process. I love you all and could not have done it without you!

Dedication

I dedicate this dissertation to my husband and family for their love, patience, and support as I completed this process.

Chapter 1: Literature Review

Not-Ready-to-Eat Entrées

Frozen food is a multi-billion dollar industry. In 2010, Packaged Facts estimated that United States (U.S.) retail sales of frozen foods totaled approximately $56 billion, with sales up 22 percent during the past five years (Aarkstore Enterprise 2010). U.S consumers are purchasing more convenience foods—prepackaged food that can be prepared quickly and easily. Sloan (2003) reported four out of 10 dinners are prepared in 30 minutes or less. Since 2006, consumer purchases of frozen food have increased by 12.4 percent (McKenna 2009). Moreover, the use of the microwave oven to prepare these meals has increased from 20 percent in 2002 to 30 percent in 2007 (Sloan 2010). A Gallop 2009 Study of Dinner reported that 91 percent of meal preparers made weekday main meals at home. Approximately 29 percent of those individuals used pre-packaged foods that required some preparation, an increase of five percent since the same survey was completed in 2007. In 2009, 51 percent of consumers said they bought more frozen foods than in the past to save money. Sales of frozen foods are projected to reach $65 billion by 2013 (Sloan 2010).

The frozen foods category includes both ready-to-eat (RTE) and not-ready-to-eat (NRTE) products. RTE products are fully cooked and only need to be reheated. In contrast, NRTE products are prepared by processors with ingredients that are not fully cooked (Food Safety and Inspection Service 2004). Such products require a consumer to perform the final cooking step to assure the safety of the product. Convenience combined with an abundance of microwave ready products produced by industry has made microwave cooking a consumer staple (United States Department of Agriculture 2011).

Outbreaks of salmonellosis linked to flash-fried NRTE chicken nuggets, strips, and stuffed chicken entrées have been identified in Australia, Canada, and the U.S (Kenny et al. 1999; Smith et al. 1999; MacDougall et al. 2004; Medus 2006a; Medus 2006b; Smith et al. 2008). Common risk contributors identified in these outbreaks included consumers prepared products that were frozen and microwavable, consumers did not understand the products were raw, and consumers did not follow the cooking instructions provided on the label (Smith et al. 1999; MacDougall et al. 2004; Medus 2006a; Medus 2006b; Smith et al. 2008).

Microwave Oven

The microwave oven is an appliance used by most consumers for its convenience because food is heated quickly and efficiently. A microwave oven heats food by use of a magnetron which supplies an alternating field of energy. Microwaves are directed in the cavity through a waveguide that helps to distribute the waves more evenly. The primary mechanism by which foods are heated in a microwave is via the microwaves interaction with water molecules (United States Department of Agriculture 2011). As the microwaves penetrate the food product water molecules begin to vibrate. The collision of the water molecules leads to the production of thermal energy resulting in the food product cooking. Microwaves are only capable of penetrating food to a depth of 1.5 inches. As a result, microwaves do not reach the center of thicker food items leading to higher surface temperatures than core temperatures. When this occurs, the remainder of the entrée heats via conduction (Pucciarelli and Benassi 2005).

An uneven distribution of heat throughout food cooked in microwave oven is often observed. This occurs when energy is reflected off product surfaces ultimately leading an uneven distribution of energy within the microwave cavity. This uneven distribution of energy may lead to the formation of hot and cold spots within a product (Farber et al. 1998). There are many parameters that can affect how a product heats. These include food mass, ionic content, and shape. The mass of a food product can affect the cooking time. The total amount of time needed to cook the entrée is increased as the mass of the product increases. Ryynanen et al. (2006) found that rectangular or irregular shaped foods heat less uniformly than foods that are spherical or round in shape. However, rounder shapes reduce corner heating, but are susceptible to focusing effects (Heddleson and Doores 2003). Heddleson and Doores (1996) determined that products with a high moisture content heat more uniformly than products with lower moisture levels. Additionally, increased sodium levels often reduce the depth of microwave penetration resulting in slower heating and more variability in temperature distribution within a product (Heddleson and Doores 1996). It is important for processors of microwave foods to consider the mechanism by which foods heat in addition to the different properties that can impact heating when developing cooking instructions for microwave entrées.

Explanation of NRTE Products

During processing, products in this category undergo a brief heat treatment in order to maintain the shape of the product and set the batter, breading, or coating. This flash frying step imparts a golden brown color on the exterior of the entrée prior to freezing and packaging (Figure 1.1). The resulting product does not look or smell raw and can lead some consumers to believe the entrée is fully cooked. As a result, consumers may only feel the need to reheat the entrée rather than fully cooking it. Consequently, pathogenic bacteria if present may not be eliminated during cooking, putting those who consumed the undercooked entrée at risk for foodborne illness.

Foodborne Illness

The World Health Organization (WHO) defines foodborne illness as "diseases, usually infectious or toxic in nature, caused by agents that enter the body through the ingestion of food". Viruses, bacteria, parasites, toxins, metals, or prions can cause foodborne illness (McCabe-Sellers and Beattie 2004; Mead 1999). The WHO estimates up to 30 percent of the population in all countries suffer from a foodborne illness each year (World Health Organization 2002).

Prepare formulation according to specifications

↓

Reduce meat particle size

↓

Add ingredients and reduce meat matrix temperature to -3.3 to -2.2°C

↓

Form nugget/strip

↓

Coat nugget/strip

↓

Batter and bread

↓

Partly cook nugget/strip at 180°C for 45 seconds

↙ ↘

Fry OR Bake

↘ ↙

Freeze nugget/strip

↓

Package nugget/strip

Figure 1.1: Processing steps for raw, breaded poultry products

Adapted from (Bucher et al. 2008)

Despite statements that the U.S. has one of the world's safest food systems, foodborne illness continues to be a public health burden (Crutchfield and Roberts 2000; Buzby et al. 2001). Each year, foods contaminated with pathogens cause unintentional injury and sometimes death to those consuming these products. Buzby et al. (2001) suggest that contaminated food products cause more deaths each year than the combined totals of the nearly 15,000 products regulated by the U.S. Consumer Product Safety Commission.

Only a fraction of cases of foodborne illness are reported making it difficult to establish the true incidence of foodborne illness (Centers for Disease Control and Prevention 2007). In the U.S., foodborne pathogens cause an estimated 47.8 million illnesses, 127,839 hospitalizations, and 3,037 deaths annually (Scallan et al. 2011). It has been estimated that the 31 known foodborne pathogens cause 9.4 million illnesses, 55,961 hospitalizations, and 1,351 deaths leaving greater than three fourths of the reported illnesses not linked to a specific cause (Scallan et al. 2011). Of the known pathogens, viral agents account for approximately 59 percent of illnesses while bacterial agents account for only 39 percent (Scallan et al. 2011).

The Centers for Disease Control and Prevention (CDC) tracks foodborne disease through the Foodborne Diseases Active Surveillance Network (FoodNet). This surveillance system helps public health officials to better understand the burden of foodborne diseases in the U.S. (Centers for Disease Control and Prevention 2005b). The network collects data on eight bacterial (*Campylobacter* spp., Shiga toxin-producing *Escherichia coli* O157:H7 and non-O157:H7, *Listeria monocytogenes*, *Salmonella*, *Shigella*, *Vibrio parahaemolyticus*, and *Yersinia enterocolitica*) and two parasitic (*Cryptosporidium parvum* and *Cyclospora cayetanensis*) foodborne pathogens. In 2010, a total of 19,089 laboratory confirmed cases of foodborne illness were confirmed. *Salmonella*, *Campylobacter*, and *Shigella* were the most frequently identified pathogens (Centers for Disease Control and Prevention 2007; Centers for Disease Control and Prevention 2010). However, the leading cause of foodborne illness, norovirus, is not tracked by FoodNet. The most recent report published by the CDC, based upon data from 2006, revealed there were 621 outbreaks with confirmed etiologies. Of those, norovirus was the most common cause accounting for 54 percent followed by *Salmonella* (Centers for Disease Control and Prevention 2009). The Center for Science in the Public Interest (CSPI) maintains a database of reported foodborne illness outbreaks in the U.S. The database is based on information compiled from the annual listings released by the CDC and state health departments. While insightful, only outbreaks with a known etiology or food vehicle are included in the database. CSPI identified 4,638 outbreaks linked to a specific food product, involving 117,136 illnesses that occurred between 1998 and 2007. The top five food categories associated with cases covering the same period were: Produce (26,735), Poultry (13,498), Beef (9,824), Seafood (7,298), and Pork (4,934). These five foods accounted for 58 percent of all outbreaks and 53 percent of all illnesses (Center for Science in the Public Interest 2009).

Foodborne illnesses are a significant economic burden from farm to fork. In 2012 Robert Scharff from The Ohio State University released an updated report estimating the total economic impact of foodborne illness in the U.S. to be $77 billion a year. This estimate takes into account medical costs (hospital services, physician services, and drugs) and quality of life losses (death, pain, suffering, and functional disability) (Table 1.1). The nationwide average cost for an individual case of foodborne illness is $1,626. The WHO suggests that individuals in the U.S. may suffer from a foodborne illness at least once every 4 – 4.5 years (World Health Organization 2002).

Epidemiology

Epidemiology, the study of disease in populations, is a key component to tracking disease (Sanderson 2007a). Foodborne illness outbreaks, most commonly detected through on-going surveillance, signal a failure in the food supply system. Dr. David Renter defines surveillance as "a continuous and systematic process of collection, analysis, interpretation, and dissemination of information on disease frequency and occurrence in a population to initiate control measures or further investigative action" (Renter 2006). The primary function of disease surveillance is to detect problems in food and water production and delivery systems that might otherwise have gone

Table 1.1: Estimated cost of foodborne illness in the United States

Pathogen	Cases	Cost Per Case ($)	Total Cost ($ Millions)
Bacillus cereus	63,400	234	15
Botulism, foodborne	55	1,680,903	93
Brucella spp.	839	21,553	18
Campylobacter spp.	845,024	8,141	6,879
Clostridium perfringens	965,958	482	466
E. coli O157:H7	63,153	10,048	635
E. coli, non-O157 STEC	112,752	1,366	154
Enterotoxicgenic *E. coli*	17,894	1,334	24
E.coli, Other	11,982	1,335	16
Listeria monocytogenes	1,591	1,282,069	2,040
Salmonella, Typhi	1,821	11,488	21
Salmonella, nontyphoidal	1,027,561	11,086	11,391
Shigella spp.	131,254	9,551	1,254
Staphylococcus	241,148	695	168
Streptococcus, foodborne	11,217	2,119	24
Vibrio cholera, toxigenic	84	2,226	0.2
Vibrio vulnificus	96	2,792,171	268
Vibrio, other	5,511	5,020	88
Vibrio parahaemolyticus	34,664	2,551	88
Yersinia enterocolitica	97,656	11,334	1,107
Cryptosporidium parvum	57,616	2,916	168
Cyclospora cayetanensis	11,407	1,483	17
Giardia lamblia	76,840	3,672	282
Toxoplasma gondii	86,686	39,869	3,456
Trichinella spiralis	156	15,104	2
Norwalk-like viruses	5,461,731	673	3,677
Rotavirus	15,433	1,154	18
Astrovirus	15,433	1,247	19
Sapovirus	15,433	1,049	16
Hepatitis A	1,566	37,073	58
Unknown Agents	38,392,704	1,178	45,,208
All illnesses	**47,780,778**	**1,626**	**77,671**

Adapted from (Scharff 2012)

undetected. There are two types of surveillance utilized by public health officials—passive and active. Passive surveillance utilizes available data on reportable diseases by state health departments (Gordis 2004). All states have legal requirements for reporting certain diseases to state health agencies (Council to Improve Foodborne Outbreak Response 2009). Active surveillance is a system in which data is being actively collected by public health officials to address a specific disease or problem (Gordis 2004).

A foodborne outbreak is considered probable when two or more individuals (from different households) experience a similar illness after eating a common food or a different food from a common source (Centers for Disease Control and Prevention; Kansas Department of Health and Environment 2008). Epidemiological investigations help determine if an outbreak has occurred, halt further progress of the outbreak, understand the reasons the outbreak occurred, institute corrective measures, and make recommendations to reduce the risk of future outbreaks (Renter 2006). There are 10 steps to any outbreak investigation (Table 1.2) (Kansas Department of Health and Environment 2004).

Each step is designed to answer the five commonly asked questions: who, what, when, where, and why of an outbreak (Kansas Department of Health and Environment 2004; Renter 2006). After a suspected outbreak is reported, a preliminary investigation is initiated to determine whether reported illnesses are part of a larger outbreak or are sporadic cases. Suspect cases are interviewed to obtain information regarding the date

Table 1.2: Steps of an outbreak investigation

1. Establish the existence of an outbreak
2. Coordinate with key personnel (local, state, and federal agencies)
3. Collect clinical specimens and food samples for testing
4. Implement control and prevention measures
5. Define cases
6. Describe the outbreak by time, place, and person
7. Develop hypotheses
8. Conduct an epidemiological study
9. Analyze data collected
10. Communicate findings of the investigation

(Kansas Department of Health and Environment 2004).

and time food was eaten, location where the food was prepared and/or eaten, the specific food consumed, and the date and onset of illness (Kansas Department of Health and Environment 2008). Based on the information collected, public health officials establish a case definition. A case definition is a set of criteria for deciding whether a person has a particular disease or health related condition (Centers for Disease Control and Prevention 2005c). The case definition helps to accurately identify and count the number of individuals affected in a given outbreak. Once an outbreak has been confirmed, public health officials implement control methods to minimize the spread of the outbreak. Common methods include: removing contaminated food, excluding those who are at high risk of spreading the disease, and practicing personal hygiene (Kansas Department of Health and Environment 2004).

The confirmation of an outbreak results in a case-control study. Case-control studies aim to establish if exposure to a pathogenic agent is related to foodborne illness.

Individuals selected for the study are sampled based on disease status and a comparison is made between the exposed (cases) and the unexposed (controls) (Sanderson 2007b). The interviews conducted during the case-control study help identify risk factors of the foodborne illness outbreak. Intervention methods targeting the identified risk factors should be implemented by health officials to prevent future outbreaks (Kansas Department of Health and Environment 2004).

Overview of Outbreaks Related to NRTE Entrées

Poultry is one of the most common food products linked to cases of salmonellosis (Center for Science in the Public Interest 2007). Since 1998, ten outbreaks of salmonellosis have been linked to NRTE poultry entrées (e.g., pre-browned, stuffed, breaded chicken entrées, chicken nuggets, chicken strips) worldwide (Table 1.3). In all ten outbreaks, consumers indicated that they considered the product fully cooked, prepared the product in a microwave, and failed to measure the internal temperature of the product prior to consumption—each element serving as a potential contributing factor to contracting a foodborne illness (Kenny et al. 1999; Smith et al. 1999; MacDougall et al. 2004; Medus 2006a; Medus 2006b).

Minnesota

Over the last 15 years, approximately 85 individuals in Minnesota have had confirmed illnesses after consuming undercooked pre-browned chicken entrées. The first U.S. outbreak, sickening at least 33 individuals, was identified in Minnesota in

Table 1.3 Foodborne illness outbreaks linked to NRTE entrées

Date	Location	No. Cases	Etiology	Product(s) Involved
1998	Australia	9	*S.* Typhimurium	Chicken Nuggets
1998 –1999	Minnesota	33	*S.* Typhimurium	Stuffed Chicken Breast
2003	British Columbia	23	*S.* Heidelberg	Chicken Nuggets and Strips
2005	Minnesota	4	*S.* Heidelberg	Stuffed Chicken Breast
2005 – 2006	Minnesota 9 other states	27 14	*S.* Enteritidis	Stuffed Chicken Breast
2006	Minnesota	3	*S.* Typhimurium	Stuffed Chicken Breast
2007	41 States	401	I 4,[5],12:i:-	Turkey Pot Pies
2008	Minnesota	4	*S.* Enteritidis	Stuffed Chicken Breast
2008	Minnesota 11 other states	14 18	*Salmonella* I4,12:i	Stuffed Chicken Breast
2010	14 States	44	*S.* Chester	Cheesy Chicken and Rice

(Kenny et al. 1999; MacDougall et al. 2004; Smith et al. 2008)

1998. The outbreak investigation identified consumer confusion about the raw nature of the product as the primary reason consumers failed to fully cook the entrées. Sickened individuals believed the product was fully cooked and only needed to be reheated, and prepared the product in a microwave oven. Furthermore, when questioned, most individuals claimed to have prepared the entrée per the manufacturer's instructions; however, when asked about specific steps it was clear most did not cook it correctly. Subsequently, in 1999, manufacturers' of the implicated products voluntarily made several changes to the product label. The words "not pre-cooked" replaced "ready to cook" on the principal display panel (PDP).

Prior to the outbreak, three recommendations for cooking were listed on the label: the conventional oven, the microwave oven, and a combination of the conventional and microwave oven. The cooking instructions were also revised to include the following statements: "not pre-cooked—cook thoroughly" and "cook to an internal temperature of 165°F." In addition to the PDP changes, the manufacturer of the implicated product altered the recommended methods of preparation. The cooking times for both the conventional oven and the microwave portion of combination cooking (e.g., conventional oven plus microwave) were lengthened. However, even though most illnesses were linked to entrées cooked in the microwave alone, no changes were made to the microwave cooking instructions (Smith et al. 1999; Smith et al. 2008).

A second outbreak was identified from August 2005 to February 2006 involving 41 cases of salmonellosis associated with raw, frozen breaded stuffed chicken entrées. As a result, the processor of the implicated entrée voluntarily recalled approximately 75,800 pounds of product. Illnesses from the outbreak prompted the U.S. Department of Agriculture's Food Safety and Inspection Service (FSIS) to once again re-examine what actions the agency should take to prevent further illnesses associated with frozen NRTE poultry products (United States Department of Agriculture-Food Safety and Inspection Service 2006a). Dr. Robert Post, Director of Labeling and Consumer Protection, released the following statement; "It is likely, that by improving the cooking instructions as well as documenting that cooking methods are validated as part of the official labeling record, a situation like the one that led to the recall could be avoided" (Post 2006).

Within a month of the recall, the FSIS sent a letter to all processors of uncooked poultry products encouraging them to voluntarily ensure their product labels adequately informed the public of the manner in which the products should be handled to ensure a safe end product. Despite the public health interventions attempted after the each outbreak, four additional outbreaks associated with raw, frozen breaded stuffed chicken entrées were identified in Minnesota between 1998 and 2008. Each additional outbreak investigation identified the same risk factors as the index outbreak in 1998—failure to read label instructions, preparation of the raw product in a microwave oven, and failure to use a food thermometer.

Australia

In 1998, an outbreak of *S*. Typhimurium was detected in South Australia. A total of 10 individuals fell ill after consuming undercooked chicken nuggets. Microwave cooking was not listed on package labels as an acceptable means of preparation; however, four individuals chose to prepare the nuggets in a microwave oven. Those who used the microwave considered the product to be fully cooked and applied a cooking time they believed to be sufficient to reheat the product. Furthermore, all individuals who were sickened did not use a food thermometer to check the internal temperature of the entrée prior to consuming (Kenny et al. 1999).

Canada

In 2003, a case-control study was initiated after an unusual spike in cases of salmonellosis was observed throughout Canada (MacDougall et al. 2004). The study sought to determine the leading risk factors for *S*. Heidelberg infections. Of all *S*. Heidelberg infections, 34 percent were traced back to chicken nuggets and chicken strips prepared within the home. When questioned as to who consumed the products, 40 percent reported the whole family, 23 percent indicated children only, and 13 percent said only adults. Of those sickened, 40 percent believed the product to be fully cooked. Moreover, 30 percent reported washing their hands less often when handling processed chicken compared to when they handle raw chicken. Over half of participants reported reading the label instructions, but approximately 12 percent reportedly making made no attempt to read the instructions.

The same risk factors were identified in all outbreaks linked to raw, breaded poultry products—consumers believed that the products were fully cooked, consumers prepared the entrée in a microwave oven, and consumers failed to take the internal temperature of the end product.

Risk factors Identified in Outbreaks Associated with NRTE Entrées

The process for manufacturing NRTE frozen breaded poultry entrées incorporates a short frying or baking step to set the surface batter and breading (Figure 1.1). This short heating process (pre-browning) causes the NRTE product to appear fully cooked to many consumers. Despite the cooked appearance of the outside, the poultry and possibly other internal ingredients remain raw. When placed side-by-side, without packaging, fully cooked and uncooked entrées have a similar appearance (Figure 1.2). The potential exists for consumers, or for food service operations, to buy NRTE entrées in bulk and discard the packaging to save freezer

A. Fully Cooked

B. Uncooked

Figure 1.2: Similar appearance of fully cooked and uncooked breaded poultry products

space. In such a scenario, cooking instructions and any precautionary statements are also discarded. Most processors only provide the cooking instructions on the box housing the entrées rather than on the individual servings of the product. A case-control study completed in Canada reported that one quarter (n=82) of participants repackaged large boxes of the product into smaller freezer portions most of the time (MacDougall et al. 2004). Furthermore, 32 percent did not retain the cooking instructions from the original packaging. Consumers then relied on their memory of how to properly prepare the entrée. In the 1998 outbreak in Australia involving chicken nuggets, a mother of one of the affected children thought that the product was fully cooked. She explained her usual practice was to heat six nuggets in the microwave for two minutes (Kenny et al. 1999). The product the mother had prepared was raw and did not list the microwave oven as an acceptable method of cooking.

From October 2005 to March 2006 a total of 41 individuals in 10 different states suffered from salmonellosis after consuming an undercooked breaded, stuffed, pre-browned chicken entrée (Smith et al. 2008). Prior to this outbreak most stuffed poultry products, including NRTE versions, were marketed as microwavable. However, after consumers fell ill from preparing the products in the microwave, processors were instructed by the FSIS to reevaluate the efficacy of their instructions in producing a safe end product (Food Safety and Inspection Service 2006a). During the reevaluation, most processors voluntarily removed the microwave cooking instructions on NRTE products. Instead of being marketed as microwavable, processors included the statement "DO NOT MICROWAVE," below the recommended cooking methods. Despite microwave cooking instructions being removed, most processors chose to alter the wording but leave the packaging appearance the same. A repeat purchaser may have continued to purchase the same product and continue to cook the product as they did previously (in the microwave) without realizing that the recommended cooking instructions had been modified to exclude microwaving. However, while most processors of NRTE frozen, breaded poultry products eliminated microwave cooking instructions from labels, some chose for them to remain as an acceptable cooking method. It is possible for consumers to assume that cooking instructions listed for one microwavable chicken entrée can be applied to all stuffed check entrées, even those not intended for preparation in the microwave oven.

Consumers are often instructed to check the internal temperature of a cooked entrée with a meat thermometer before consuming. In an attempt to improve consumer adherence to this recommendation, processors now include on the PDP a statement such as “UNCOOKED: For food safety, cook to a minimum internal temperature of 165°F as measured by a meat thermometer.” Some processors now include an image of how to properly check the internal temperature of a stuffed chicken entrée (Figure 1.3).

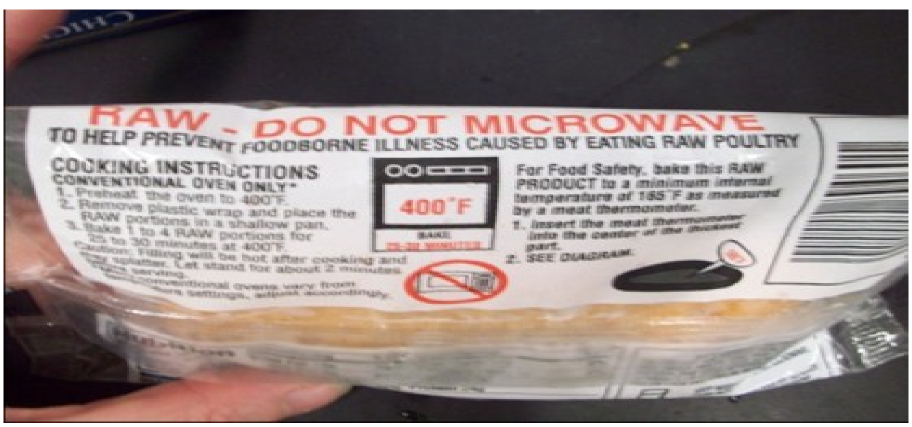


Figure 1.3: Instructions on how to properly check the internal temperature of the end product.

The enhanced instructions typically ask consumers to check the internal entrée temperature in the thickest portion. While the middle is the thickest portion it may not be the slowest heating region. By following this single measurement approach, consumers may believe the entrée is fully cooked throughout when in fact portions may have failed to reach a safe end-point temperature. Consumers should be encouraged to take multiple temperature readings throughout the product rather than a single reading in the thickest portion. This approach better ensures that a consumer could identify when a safe end temperature was not achieved throughout the entire product.

Government Response

In light of the 2005 - 2006 outbreak linked to frozen, stuffed, breaded, prebrowned microwavable chicken entrées, a voluntary recall involving 75,800 pounds of stuffed chicken entrées was initiated by the manufacturer (Smith et al. 2008). Following the voluntary recall, the FSIS sent a letter to all processing plants in the U.S. manufacturing these products instructing them to reevaluate the adequacy of their current labels (Food Safety and Inspection Service 2006a). The letter was sent because continuous outbreaks highlighted that consumers do not understand product labels and believe NRTE products are precooked. FSIS expressed their concern that such products do not adequately inform consumers how to properly handle the entrée to obtain a safe end product. Therefore, the FSIS mandated that a statement must appear on the PDP stating, "Uncooked: Must be Cooked to an Internal Temperature of 165°F as Measured by a Food Thermometer." Moreover, any cooking methods listed on the label must be validated by the manufacturer to ensure lethality against bacterial foodborne pathogens should they be present in the entrée.

A second document released by the National Advisory Committee on the Microbiological Criteria for Foods (NACMCF) served as guidance to all manufacturers on how to meet the requirements mandated by the FSIS (National Advisory Committee on the Microbiological Criteria for Foods 2006). Despite the majority of individuals falling ill from consuming NRTE products prepared in the microwave oven, the FSIS did not require that microwave cooking instructions be removed. Within this document, NACMCF explained that the delivery of adequate lethality during cooking is affected by product composition, shape, and temperature before cooking. It reiterated the importance of clear label instructions because how consumers interpret the given safety information may lead to confusion and subsequent undercooking of the product. NACMCF also reviewed the advantages and disadvantages associated with each method that may be used to prepare entrées similar to those implicated to salmonellosis outbreaks (Table 1.4).

Additionally, stated that the improved instructions provided by processors must list the temperature at which no additional heating or holding time is needed to produce a microbiologically safe product. Practical instructions must be available to consumers, as overly complex instructions may be difficult for consumers to follow. Most consumers do not cook with a food thermometer when preparing convenience products. Therefore, manufacturers must develop instructions using the worst case scenario—a consumer does not follow a single recommendation.

Table 1.4: Summary of cooking methods commonly recommended on NRTE entrées

Method	Advantages	Disadvantages
Deep Fat Frying	• Product surface is in contact with the oil.	• Difficulty in taking the internal temperature when submerged in oil. • Undercooking of interior because exterior appears fully cooked.
Microwave Oven	• Faster heat up time • Less risk of cross-contamination	• Uneven heating affected by product characteristics, cooking container, product placement within oven, presence absence of a turntable. • Differences in equipment making it difficult to create standardized cooking instructions. • Inexperienced cooks may choose inappropriate settings. • Difficult to measure internal temperature while cooking. • Difference in wattages between microwaves.
Conventional Oven	• Product remains at lethal temperature for an extended period of time.	• Crust formation slows heat penetration. • Product shape may lead to uneven cooking.

Adapted from (National Advisory Committee on the Microbiological Criteria for Foods 2006)

The instructions must have a built in margin of error. Moreover, they must consider how consumers will interpret the instructions and account for the inherent variability in microwave ovens. Manufacturers must choose their wording carefully because stating to cook the entrée on "high" for a designated period of time suggests that all microwaves operate at the same level of power. In summary, the NACMCF recommends the PDP state the entrée is NRTE, raw, and needs to be fully cooked before being consumed.

Food Labels

Food labels should aid consumers in making informed decisions about products they purchase. In 1966, the U.S. Fair Packaging and Labeling Act was passed and required all consumer products involved in interstate commerce to be honestly and informatively labeled. Almost 30 years later, in 1990, the Nutrition Labeling and Education Act was written into law, stipulating that all packaged foods bear nutrition labeling and that all health claims for food be consistent with terms defined by the U.S. Food and Drug Administration (FDA). Concurrently, the food ingredient panel, serving sizes, and terms such as “low fat” and “light” were standardized (Food and Drug Administration 2010b). In 1994, safe handling instructions were required to be placed on all raw or partially cooked meat and poultry products (Food Safety and Inspection Service 1994). Today, product labels serve as the cornerstone to communicating information to consumers (Sloan 2003). From a public health standpoint, providing consumers food safety information is important because consumers have control over food preparation in their homes and can potentially reduce the risk of illness through their actions (Ralston and Lin 2001).

The information presented on food labels should be accurate and simple. Ariely (2000) determined that too much information may be overwhelming to consumers or target audience. Similarly, Carter-Young et al. (2007) reported that overly complicated information might deter consumers from making a food purchase. In addition to complex instructions, there are multiple factors that may also limit the effectiveness of a label. These include: consumers not taking time to read product labels, the size of the print, consumers' concerns about accuracy, and a lack of understanding due to language barriers. Nayga et al. (1998) reported that time restraints experienced by working consumers may limit the time spent reading food labels prior to preparation. A number of studies have found that consumers believe the print size used on labels is too small (Harper et al. 2007). The size of the print can limit the way consumers understand information on food labels. Sloan (2003) suggests that manufacturers should create larger labels, catering to older individuals such as baby boomers that will account for 24 percent of the U.S. population by 2014. Buzby and Ready (1996), through surveys, found 55.9 percent of consumers used food labels; however, only 10.2 percent fully trusted the information being presented. Furthermore, McIlveen (2002) reported that out of 103 consumers, 19 percent found labels difficult to understand. According to Rothman et al. (2006), approximately 90 million Americans do not have the necessary skill set to read and understand product labels. When designing new product labels, manufacturers should consider such factors to increase the effectiveness of the information being presented to consumers.

Safe Handling Instructions

Consumers use food safety attributes when making their food purchasing decisions (Caswell 1998). The federal government and the meat industry have begun to focus on labeling options as a means of providing food safety information to consumers. Ralston and Lin (2001) suggest food labels can serve both the public health goal of reducing foodborne illness and the informational goal of providing the necessary information to consumers so that they can take informed risks should they decide not to follow the provided recommendations.

In 1972, the American Public Health Association, individual consumers, and other public health groups sued the U.S. Department of Agriculture (USDA). They argued that labels on meat and poultry products were insufficient and that the information presented to consumers was misleading (Ralston and Lin 2001). The USDA successfully fought the lawsuit, claiming that consumers' education should be sufficient, eliminating the need to place warning labels on the products. However, the agency was forced to reconsider their stance following the 1993 *E. coli* O157:H7 outbreak, in which four children died and hundreds of other individuals were sickened as a result of consuming undercooked hamburger patties prepared at Jack in the Box restaurants (Powell and Leiss 1997). Subsequently, in 1994, mandatory safe handling labels were required on all raw meat and poultry products (Ralston and Lin 2001). The requirement was the first move by the agency towards improving the food safety information available on product labels. Prior to the final implementation, the USDA conducted focus groups with household food preparers to determine what consumers desired on the labels. Participants revealed that they wanted short instructions, icons, and an explanation of the importance of following said instructions. The final design (Figure 1.4) instructs consumers to keep food refrigerated or frozen, avoid cross-contamination, cook food thoroughly, and refrigerate leftovers immediately.

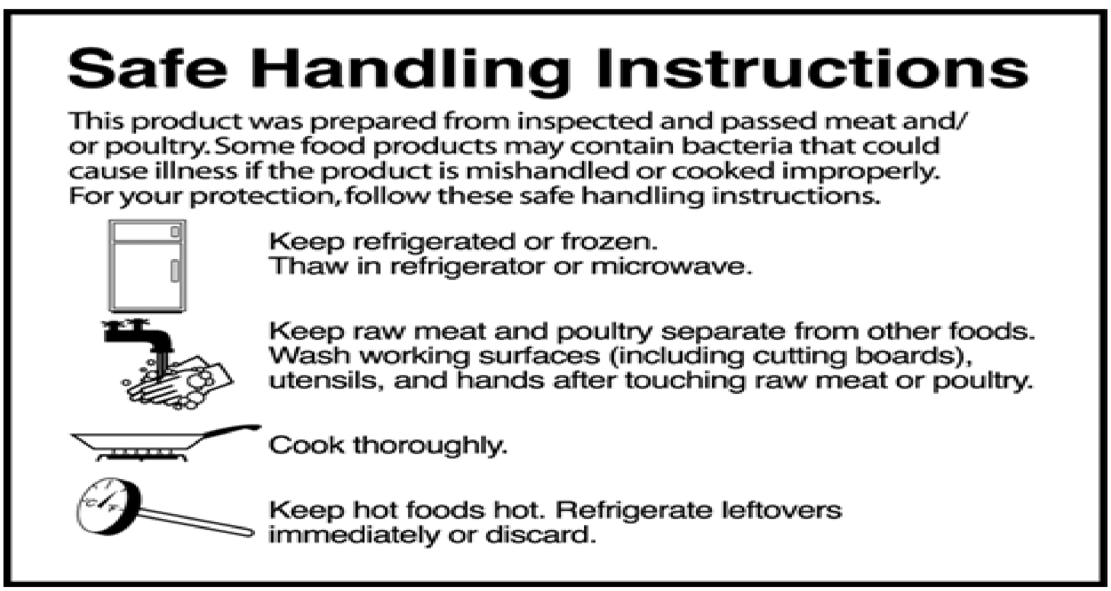


Figure 1.4: Safe handling instructions found on all raw meat and poultry products

During the first years of the label implementation, Yang et al. (2000) evaluated consumers' awareness of safe-handling instructions and the influence of these instructions during preparation. A total of 14,262 consumers were interviewed. Approximately 51 percent of respondents stated they had seen the label. Of those who had seen the label, 79 percent reported reading the label; slightly more than a third of participants self-reported they altered their behavior as a result of the information presented on the label. Additionally, women were more aware of the label compared to men and awareness increased with age (Yang 2000).

While participants reported the labels altered their preparation practices, the labels did not successfully prevent them from engaging in risky food handling behaviors. Overall, the authors concluded that labels were a reasonable method for disseminating food safety information to consumers, but additional measures were needed to motivate consumers to alter unsafe food handling behaviors (Yang 2000). Yang et al. (2000) demonstrated that self-report surveys are useful in determining the influence labels have on consumers' preparation practices. Self-report surveys are increasingly being used by researchers in an attempt to evaluate consumers' food safety practices. While informational, there are important limitations associated with this approach.

Warning Labels

Outbreaks associated with NRTE entrées have prompted government agencies and processors within the food industry to discuss adding warning labels to product packaging. Researchers suggest bright colors and short sentences may improve label comprehension (Lehto and Miller 1988). The addition of such labels would present consumers with information on which to base food safety decisions, assuming such labels were read, internalized, and acted upon (Ariely 2000). However, the overall effectiveness of the label would be dependent upon a consumer's perceived risk. McIntosh et al. (1994) reported that a consumer's willingness to change is based on their perception and beliefs. If little-to-no risk is perceived, consumers will most likely ignore the attached label and thus not alter their current food handling practices. The presence of a warning label does not guarantee consumers will utilize the information. The overall goal of adding warning labels is to prevent consumers from engaging in behaviors that are unsafe and simultaneously promote appropriate behaviors when the product is being prepared. While most consumers say—at least in surveys—the addition of labels would be beneficial, some feel that they are ineffective and may discourage consumers from purchasing the product (Carter-Young et al. 2007).

Health Behavior Theories

Behavioral intentions are an integral part of social cognition models used to access an individual's attitude about food safety. While most consumer-based research studies aim to better understand consumer behavior very few studies have applied the constructs of these models. A number of theories exist; however, there are four models consistently used in research conducted on health behavior. These include: the Health Belief Model, the Protection Motivation Theory, the Theory of Reasoned Behavior

(TRA), and the Theory of Planned Behavior (TPB). The behavior models assist researchers in gaining a fundamental understanding of consumer behavior. The constructs of each theory are similar; however, differences lie within the emphasis used to explain behavioral outcomes. Table 1.4 provides an overview of each of these theories. TPB is the best known theory in the field of food safety behavioral research (Glanz et al. 2002). This theory postulates that a person's behavior is planned and that planning is part of the function of their intention. An individual's intention has been identified as the biggest determinant of behavior (Redmond and Griffith 2003a). Two separate studies have applied the TPB to explain the factors influencing food handling behaviors of adults. The results indicated that TPB did not significantly predict a person's food handling behaviors (Redmond and Griffith 2003a). In contrast, Mullan in 1997, as reported by Redmond and Griffith, applied TRA and found a strong correlation between behavioral intention and actual observed food safety behaviors (Redmond and Griffith 2003a). Consumer intentions toward food handling are still understudied, but the few studies completed have shown the models to be ineffective at predicting food handling behaviors.

Table 1.5: Health behavior theories

Theory	Principles	Key Elements
Health Belief Model	An individual's behavior is determined by their personal beliefs or perceptions about a disease and the strategies to decrease its occurrence. Their preventative behavior is influenced by five factors.	• **Perceived susceptibility**: one's chances of getting a disease. • **Perceived severity**: one's evaluation of the severity of the disease • **Perceived benefit**: one's evaluation of how well an action will reduce the risk of the disease • **Perceived Barriers**: one's evaluation of obstacles in the way of adopting a new behavior. • **Cues to Action**: events or strategies that increase one's motivation.
Protection Motivation Theory	An individual's intention to protect themselves is based on four factors.	• Perceived severity of a threatening event. • Perceived probability (or vulnerability) of the occurrence. • Efficacy of recommended preventative behavior that can remove the threat (perceived response efficacy). • Belief that one can carry out the recommended preventative behavior (perceived self-efficacy)
Theory of Reasoned Action	An individual's performance of a specific behavior is driven by an individual's motivational factors.	• TRA states that an individual's behavior is dependent upon an individual's attitude toward the behavior and subject norms surrounding the performance of the behavior. • Attitude can be defined as an individual's positive or negative feelings about performing a behavior. • Subjective norm can be defined as an individual's perception of whether people important to the individual approve or disapprove of the behavior to be performed.
Theory of Planned Behavior		• TPB is an extension of TRA with an additional factor: • Perceived behavior control can be defined as the degree of control an individual perceives he/she needs to perform the behavior

Adapted from (Glanz et al. 2002)

Observation versus Survey Methodology

There is a lack of research examining whether a consumer's intent translates into actual behavior. Previous foodborne disease outbreak investigations have identified poor personal hygiene, cross-contamination, and temperature abuse as the three leading factors contributing most significantly to foodborne illness (Fein et al. 1995). Self-report surveys and direct observation are the two qualitative methods relied upon most often to better understand consumer behavior. Survey responses suggest consumers possess the knowledge necessary to prevent foodborne illness within their homes. However, despite self-reported awareness of food safety recommendations, results obtained from direct observation revealed consumers do not always follow recommended practices. Jay et al. (1999) studied consumer food handling practices using video observation as participants were continuously monitored within their home over a two week period. Jay and colleagues observed poor personal hygiene, failure to remove meat packaging from the food preparation area, pets resting on countertops, consumers frequently touching their face, nose, and/or hair during meal preparation, and leaving food at room temperature for longer than two hours (Jay et al. 1999).

While survey results imply that consumers know what behaviors prevent foodborne illness, observational studies reveal that knowledge alone does not guarantee implementation of safe food handling. Abbot et al. (2009) found that participants admitted to engaging in less than half of the recommended safe-food handling behaviors even though they correctly answered questions asking what behaviors prevent foodborne illness. Likewise, Clayton et al. (2003), when probing participants as to why they did not engage in safe food handling practices, found 45 percent could not provide a reason as to why they did not implement the behaviors.

Observational Research

Each sector involved in the chain of food production is responsible for the safety of food; no one sector carries sole responsibility. However, consumers perform the final step in food preparation making them the last "line of defense" (Redmond and Griffith 2003b). Studies have reported that 12 – 80 percent of foodborne illnesses results from poor food handling and hygiene practices in the home (Haapala and Probart 2004; Redmond and Griffith 2004a; Haysom and Sharp 2005; Roufous 2007; Mead et al. 1999; Anderson et al. 2004). Worsfold and Griffith (1997) estimated that 71 percent of all meals are prepared at home. Therefore, safety measures taken by consumers can play an important role in the prevention of foodborne illness.

A limited amount of information is known about how food is handled after purchase by consumers. Food safety experts have accepted the fact that consumers' improper food handling and preparation practices in their own kitchens can cause foodborne illness; however, consumers themselves are still largely unaware of this fact (Scott 1999). Byrd-Bredbenner and colleagues (2007) suggest consumers do not fully understand the magnitude of control they have in their own kitchen to prevent the risk of contracting foodborne illness. In contrast, Milton and Mullan (2010) reported that consumers do acknowledge the importance of safe food handling practices, but believe that food-related illness is not a domestic issue. A national survey conducted in 2009 found 86 percent of respondents did not believe any member of their household—including themselves—had experienced food poisoning in the last year (Clayton et al. 2003). Altekruse and colleagues (1996) reported 65 percent of study participants attributed foodborne illness to food prepared in a restaurant. Similarly, Woodburn and Raab (1997) found most consumers believed that food from bars and restaurants have a higher likelihood of being contaminated with foodborne pathogens than food prepared by consumers themselves. However, a small portion of consumers do recognize the risk of foodborne illness in private homes. Fein et al. (1995) found 17 percent of respondents believed foodborne illness was due to their food handling practices. Similarly, 28 percent of individuals completing the Home Food Safety—It's in Your Hands—survey administered by the Academy of Nutrition and Dietetics and ConAgra felt it was extremely common for people to get sick from food prepared within the home (Cody and Hogue 2003). Consumers' underestimation of foodborne illness linked to the home may be a direct result of optimistic bias in which consumers consider themselves immune (or less likely than others) to experience negative life events (Redmond and Griffith 2003b). Therefore, in relation to foodborne illness, consumers are optimistically biased by their belief they will never experience a foodborne illness but, if they do, it will be from consuming food prepared at a restaurant.

Health related behaviors, such as those associated with food safety, are influenced by cultural, environmental, and socioeconomic factors. Moreover, psychological determinants (attitude, beliefs, knowledge, and values) also play a role. These cognitive precursors help justify a consumer's motivation for implementing the recommended behaviors. A consumer's intention can be defined by their attitude toward performing a specific behavior (i.e., behaviors that will prevent and protect them from foodborne illness) and their subjective norms (Ajzen and Fishbein 1980). Subjective norms are defined by the belief that others approve or disapprove of a specific behavior or a person's motivation to comply with relevant others (Montano and Kasprzyk 2001).

Qualitative research methods are designed to access consumers' knowledge of food handling practices, perceptions of food safety, and intentions for implementing recommended food safety behaviors (Redmond and Griffith 2003a). The majority of information collected on consumers' food handling behaviors thus far has been largely anecdotal (surveys and face-to-face interviews) (Redmond and Griffith 2003a). The goal of consumer- based research is to provide information that will help develop effective communication strategies to promote food safety. Foster and Kaferstein (1985) reported that only when consumers' attitudes and food safety practices are known is it possible to create effective strategies to encourage safe food handling.

Information regarding foodborne illness as a result of food prepared in a domestic setting comes from two sources—foodborne illness outbreaks and consumer-based research. A limited number of studies have evaluated how food is stored, prepared, and consumed in the home. In a review of 88 consumer food handling studies, Redmond and Griffith (2003) found only 15 percent employed observational methodologies. Researchers, when studying consumer behavior through observation, often use one of two approaches. In the first approach, participant observation, a researcher takes an active part in the study and completes the tasks alongside other participants. In non-participant, or direct, observation the researcher collects data by covertly observing a participant's behavior, but is not actively involved in the study. Consumer based studies have revealed consumers make numerous errors during meal preparation (Worsfold and Griffith 1997; Jay et al. 1999; Scott 1999; Redmond and Griffith 2003b; Kendall et al. 2004; Redmond and Griffith 2004a; Redmond and Griffith 2004b; Anderson et al. 2004).

Handwashing

Poor personal hygiene is one of the main factors contributing to foodborne illness. Consumers, when surveyed, self-reported handwashing was the single best behavior one could practice to prevent foodborne illness (Clayton et al. 2002). Altekruse and colleagues (1996) reported 86 percent of participants felt handwashing could reduce the risk of foodborne illness. Moreover, most consumers correctly identified events in which handwashing should be implemented during meal preparation (e.g., before starting food preparation, after handling raw meat or poultry, after touching the garbage can, etc.) (Scott 1999). Cody and Hogue (2003) found the majority of participants claimed to have washed their hands before meal preparation (90 percent) and after handling raw meat (86 percent). Similarly, Scott and Herbold (2010) found 100 percent of participants reported washing their hands after handling raw meat. In general, data collected from self-report surveys suggest consumers consider themselves knowledgeable about handwashing and understand the role of this practice in the prevention of foodborne illness (Scott et al. 2010).

Answers provided on self-report surveys, as discussed above, portray consumers as overly confident in their food handling practices. A clear discrepancy exists when comparing answers provided on surveys to observed behavior. Observation is the optimal approach a researcher can utilize to better understand the relationship between consumer's knowledge and actual behavior. This approach allows researchers to observe consumers' food handling practices instead of relying on consumers providing data through surveys. Very few studies have combined direct observation with self-report surveys within the same study; however, those that have found an inconsistency between what individuals report and what they actually practice (Jay et al. 1999;

Clayton et al. 2003; Redmond and Griffith 2003b; Redmond and Griffith 2003a; Anderson et al. 2004). For example, Dharod and colleagues (2007) observed only a quarter of participants washing their hands before meal preparation compared to the self-reported 90 percent that claimed to always wash their hands before preparing food. Anderson et al. (2004) observed an average of seven failure-to-wash-hands instances per participant during meal preparation. A failure was defined as a behavior that should have prompted participants to wash their hands. Of the 727 failure-to-wash-hands observations, the most common failure occurred when participants switched between handling raw meat and fresh RTE foods (Anderson et al. 2004). All participants in Scott and Herbold's (2010) study self-reported always washing their hands after handling raw meat. However, video data revealed less than a third of those who claimed to actually washed their hands after handling raw meat. In contrast, Kendall et al. (2004) found agreement between self-reported and actual behavior when evaluating handwashing. Over 90 percent of participants reported and were observed washing their hands before preparing food. However, of those same participants, only half washed their hands after handling raw meat even though they reported always washing their hands after contact with raw meat (Kendall et al. 2004).

As demonstrated, survey methods are beneficial for determining the level of food safety knowledge consumers possess, but do not reveal actual consumer actions during food preparation. Dharod et al. (2007) suggested that individuals with a poor attitude toward food safety may fail to implement recommended behaviors despite having the necessary knowledge to do so. For example, Clayton and Griffith (2003) found that even though 95 percent of participants considered handwashing an important behavior only 55 percent believed that it would prevent food poisoning. Therefore, a poor food safety attitude may prevent consumers from implementing specific behaviors, such as handwashing, because they do not believe it will ultimately protect them from foodborne illness.

Cross-contamination

Cross-contamination occurs when harmful bacteria are transferred to food due to improper handling. Cross-contamination can occur directly (i.e., source of bacteria comes in direct contact with food/utensils) or indirectly (i.e., using the same knife to cut both raw and RTE foods). During observational studies researchers often request that participants prepare a meal consisting of both raw and RTE ingredients (i.e., chicken with a side salad). By handling both raw and RTE ingredients, a researcher has created an environment in which cross-contamination may occur if correct food handling practices are not implemented.

Survey results suggest consumers believe they take the necessary precautions to reduce the risk of cross-contamination. For example, Clayton et al. (2002) found that participants were confident in their ability to prevent cross-contamination while preparing foods, as 80 percent reported always using separate utensils when handling both raw and RTE foods. Similarly, 70 percent of consumers who completed the "It's in Your Hands" survey reported always washing the countertop after contact with raw meat. Likewise, 83 percent of the same participants reported using different cutting boards for handling both raw and RTE foods (Cody and Hogue 2003). While surveys depict consumers as being confident they can prevent cross-contamination during meal preparation, observational research has revealed the opposite—consumers engage in numerous risky food handling practices.

Nesbitt and colleagues (2009) found that participants were confident they were practicing behaviors necessary to reduce the risk of cross-contamination (i.e., use of different cutting boards between handling raw and fully cooked meat). However, when observed during meal preparation, 74 percent of participants failed to use a separate cutting board when preparing raw and RTE foods (Nesbitt et al. 2009). Anderson et al. (2004) identified 477 instances in which cross-contamination occurred due to participants' suboptimal food handling practices. Byrd-Bredbenner et al. (2007) observed 60 percent of participants not wash their hands after handling raw chicken. Likewise, Jay et al. (1999) observed 47 percent of participants neglected to wash their hands after handling raw meat and proceeded to indirectly contaminate other objects within the kitchen (utensils, dish rags, garbage cans). Research suggests that chances for cross-contamination in a domestic kitchen are greater than in a commercial kitchen. Cross-contamination may occur because there are a wide variety of foods being processed in a domestic kitchen, the kitchen is often used for activities other than preparing food, and many consumers do not have adequate counter space to maintain a clear separation between raw and RTE foods. Collectively, all factors could result in an increased risk of cross-contamination.

Inadequate Cooking

The final factor most commonly linked to foodborne illness outbreaks is inadequate cooking. Research shows that consumers rarely use food thermometers. Most study participants report never using a food thermometer when cooking meat. Instead, consumers felt confident in other techniques used to determine doneness (i.e. color, time, etc.) (Nesbitt et al. 2009). Through focus groups, Gauci and Gauci (2005) found that participants do not use a food thermometer to determine doneness. Instead participants described what they felt were reliable alternatives. These included tasting the food, touching the outside of the entrée, or visually checking the exterior of the food. Scott and Herbold (2010) found 50 percent of participants felt it was effective to use color as an indicator of doneness. Similarly, Anderson et al. (2004) found the majority of participants (76 percent) used either a knife or poked the meat with another utensil. However, when thermometer use was addressed on surveys, approximately 30 subjects reported owning a food thermometer, and of those, one-fifth reported always using it during meal preparation and doing so correctly. Furthermore, as a result of not checking the internal temperature of the prepared entrée, 30 percent of participants undercooked their entrée (Anderson et al. 2004). Consumers who completed the "It's in Your Hands" survey reported knowing the recommended end temperature of beef, but when asked to provide the temperature only nine percent provided the correct answer (Cody and Hogue 2003). Overall, most consumers understand that cooking meat and poultry to the recommended end temperature decreases the risk of foodborne illness; however, consumers are generally unaware of the internal temperature at which meat and poultry are considered fully cooked. Bruhn (1997) suggested motivation and compliance to safety guidelines is enhanced by knowing the consequences. Likewise, McCurdy and colleagues (2005) believe that using a thermometer is the one food safety behavior that offers the most opportunity for a positive change. Overall, consumers should use a food thermometer because it is the only method an individual can use to accurately determine if meat and poultry items are fully cooked; however, proper use of food thermometers must be stressed.

Observation of Food Service Employees

Many consumers find that the time they have to devote to home meal preparation has decreased, and thus, more consumers have turned to eating food prepared outside the home. Every day, 44 percent of U.S. adults eat food purchased from a restaurant (Center for Science in the Public Interest 2008). From 1990 to 2006, 41 percent of all identified foodborne illness outbreaks were traced to restaurants (Center for Science in the Public Interest 2008). The WHO has identified five risk factors that can lead to foodborne illness. These include: improper cooking procedures, temperature abuse during storage, food handlers lack of personal hygiene, cross-contamination between raw and fresh RTE foods, and acquiring food from unsafe sources (Chapman et al. 2010; Lubran et al. 2010). Food handlers have complete control over all practices except food from unsafe sources. Furthermore, these risk factors can be minimized if safe food handling practices are implemented. Therefore, in relation to food prepared outside the home, foodservice employees play an integral role in the prevention of foodborne illness.

Several studies have assessed the behavior(s) of food service employees during food preparation using a qualitative approach. The majority of studies have used self-report questionnaires and focus groups to gain information about knowledge, attitudes, and preparation practices of food handlers. While informative, these methods do not provide detailed data on how often or under what conditions unsafe food handling practices occur. For example, when questioned, 62 percent of UK caterers reported washing their hands after every necessary task (IFF Research Ltd 2002). However, when observed, Clayton and Griffith (2004) found only 14 percent of caterers performed adequate hygiene activities at all necessary times. The difference in data demonstrates the drawback of surveys. When administering surveys, researchers are forced to rely on the participant providing an accurate portrayal of their food handling practices.

Therefore, given the discrepancies between self-report and actual behavior, direct observation is the more ideal approach for evaluating behavior.

Direct observation has been used in very few studies to document food handlers' behaviors. Researchers who have used direct observation have found a lower compliance rate with recommended food safety behaviors compared to self-report data (Allwood et al. 2004). The three main behaviors targeted in surveys have been handwashing, cross-contamination, and thermometer use. However, very little observational research has been completed on the latter two; therefore, this discussion will focus only on handwashing.

CDC identified poor personal hygiene as one of the most common causes of foodborne disease (Allwood et al. 2004; Centers for Disease Control and Prevention 2011). Therefore, in order to lower the risk of foodborne illness, it is imperative that individuals practice correct handwashing during food preparation. In 2002, Clayton and colleagues interviewed 137 food handlers. The majority, 84 percent, believed handwashing was the most important behavior to prevent foodborne illness. However, even though they identified handwashing as important, over half of participants admitted to not carrying out the recommended behaviors at the appropriate times (Clayton et al. 2002). Furthermore, the FDA, during audits, observed improper handwashing in almost three-fourths of restaurants visited (Green et al. 2007). When observing personal hygiene in the workplace, researchers rely on the definition of handwashing set forth in the FDA's Food Code for Food Service and Retail Establishments. The Food Code states handwashing should include warm water, soap, and friction between hands for 10 to 15 seconds, rinsing, and drying with a clean towel or hot air (Food and Drug Administration 2010a). A majority of studies reported compliance with the Food Code to be low. For example, Green and colleagues, through surveys, found food handlers reported following the Food Code only 27 percent of the time (Green et al. 2006; Green et al. 2007). Similarly, Strohbehn et al. (2008) observed employees in four separate food service scenarios and found restaurants had the lowest compliance rate (5 percent), followed by school employees (22 percent), childcare workers (31 percent), and assisted living center employees (33 percent).

Focus groups have aided researchers in identifying factors that impact why handwashing is not being implemented in the work place. Participants revealed that having too few sinks, time pressures, inadequate facilities/supplies, lack of accountability, lack of involvement of managers, organizations do not emphasize the importance of handwashing, and employees are not able to wash their hands when there is a high order volume to prepare because the most important thing is getting food to the customer (Green and Selman 2005; Pragle et al. 2007; Howells et al. 2008). Data from all studies suggest handwashing is not a common practice among food service employees thereby suggesting food service workers either do not know when they are supposed to be washing their hands or they simply choose not to wash their hands.

Food Safety Interventions

Consumer Targeted Intervention

Redmond and Griffith (2006), using closed-circuit television and observational checklists, observed participants preparing the same meal (consisting of both raw and RTE foods) on three separate occasions over a three month period. The second and third meal preparation sessions took place approximately three and six weeks, respectively, after the initial session. Following the first session, brochures, posters, refrigerator magnets, and newspaper articles addressing key food safety behaviors were distributed to each participant's home and throughout their communities.

During the first meal preparation session zero participants washed their hands correctly. Subsequently, after exposure to intervention materials 21 percent correctly washed their hands after handling raw chicken. However, six weeks after the intervention only 13 percent continued to wash their hands correctly. Moreover, the same participants failed to wash their hands an average of 11 times per meal preparation session. In regards to other necessary food handling behaviors (cross-contamination, thermometer use, etc.), 79 percent of participants practiced such behaviors after exposure to intervention materials. However, only 71 percent maintained that improvement six weeks after the initial observation.

Following the completion of the study, 88 percent of participants could recall seeing the intervention materials. Redmond and Griffith found those who recalled more than one intervention improved their behavior to a greater extent compared to those who could only recall a single intervention. Overall, results suggest food safety interventions are effective in improving behavioral compliance, but are not compelling enough to be maintained for an extended period of time. Therefore, new approaches need to be developed to lengthen the maintenance period (Redmond and Griffith 2006).

Food Service Intervention

A limited amount of research has been published examining food handlers' food preparation practices pre-and-post-food safety interventions. A ten year study completed by the FDA's National Retail Food Team found food service establishments continually do not comply with the requirements set forth in the Food Code (Food and Drug Administration 2010a). In 2008, Roberts et al. sought to determine the impact ServSafe® training had on a food handler's preparation practices. All employees participating in the study were required to attend ServSafe® training. Additionally, each employee was asked to complete a self-report survey and participate in a three hour observational session before and after intervention. In doing so, researchers were able to directly compare survey answers to participant's food handling practices before and after intervention. Overall, behavioral compliance remained low for preventing or avoiding cross-contamination and using thermometers, but increased significantly for handwashing. Prior to the training course, 62.5 percent of employees washed their hands at the beginning of their shift, but after the course, all employees did so correctly. However, research suggests that an increase in knowledge alone does not guarantee a change in all behaviors. For example, participants demonstrated adequate knowledge when reporting what temperature food should reach when reheated. The overall mean increased from 71.2 percent to 85.5 percent of participants knowing that the temperature of leftovers should be checked after reheating; however, when observed only 20 percent did so (Roberts et al. 2008).

Chapman et al. (2010) aimed to reduce risky food handling practices in commercial kitchens by distributing food safety infosheets. The infosheets, designed specifically for food handlers, highlighted the importance of key food handling behaviors and offered narratives in an attempt to bring about a behavioral change. Prior to the introduction of the infosheets participants were observed preparing food. Each week, for seven weeks, a different infosheet was strategically placed throughout the kitchen. At the end of the seven weeks, the same employees were once again videotaped and their behaviors were observed. Chapman and colleagues found that food handlers demonstrated a significant increase in handwashing and a reduction in events potentially leading to indirect contamination.

Collectively, research suggests interventions can have a positive influence on food handlers. However, Redmond and Griffith (2006) suggested that the slightest behavioral change may not be maintained. Therefore, an increase in knowledge alone is not sufficient to motivate an individual to continually perform correct food handling practices. Most food safety initiatives aim to increase knowledge; however, researchers evaluating such initiatives suggest that more emphasis be placed on why the behavior should be altered and the proposed benefit to the individual for performing the behavior. Although food safety interventions were effective in influencing food handlers' behaviors, alone they do not provide a solution for risk reduction.

Benefits of Qualitative Research

As stated by Berg (2007), qualitative research refers to the meanings, concepts, definitions, characteristics, symbols, and descriptions of things in their existing environment. Data obtained from qualitative research allows individuals to be understood in "their own terms and in their natural setting" (Berg 2007). Direct observation, where an observer openly watches participants prepare a meal, is useful in collecting data on consumers' food handling behaviors. Social scientists believe direct observation of human behavior is superior to other methods of data collection (Redmond and Griffith 2003b). Data gathered through direct observation more accurately reflects the true behavior of participants compared to the information provided on self-report surveys. When directly comparing data gathered from self-report surveys and observational studies a gap has often been identified between an individual's intended behavior and their actual behavior. Observational studies revealed consumers make a variety of errors during meal preparation. Anderson et al. (2004) stated the only reliable measure for determining the effectiveness of an intervention is to directly observe a consumer's food preparation practices. Overall, observational methodology has two advantages over self-report and anecdotal methods: (1) observation captures actual behavior and (2) behavior is captured in context (Gittelsohn et al. 1997).

Limitations of Self-Reported Surveys

Different strategies for data collection have been used to better understand consumers' food handling practices. A common method used is survey methods. While useful, survey methods are heavily reliant on a participant's memory. A personal account of actions may or may not depict actual behavior. For example, the FDA in combination with the FSIS conducted the "Food Safety Survey" in 1998 after safe handling instructions had been on packaging of meat and poultry for four years. Out of 2,001 respondents, 65 percent said they had seen the instructions and of those, 30 percent altered their behavior (Ralston and Lin 2001). While a number of respondents reported a positive change in their behavior, it was difficult to determine if the label truly brought about the change. The possibility exists that an individual already concerned about foodborne illness may be more aware of the label and more careful with their food handling; therefore, the change in behavior was due to the awareness of foodborne illness rather than seeing the label. Reporting bias should be considered when administering surveys due to the ability of the bias to skew the results in a positive direction. Reporting bias occurs when an individual is distorting the given information to promote a particular point of view (Frewer et al. 1997). Surveys are also structured and may limit participants to a specific set of responses. They may be forced to choose an answer that most closely relates to them rather than having a response that accurately describes their behaviors.

Limitations to Observation

Despite being an improvement over other qualitative methods, observation does have limitations. First, it is expensive and time consuming. In participant observation, the researcher is forced to make quick coding decisions while observing in a fast-paced setting. As a result, it may be difficult to document all details that are important to the study (i.e., behaviors completed correctly, mistakes made during meal preparation). The researcher may choose to expand their notes following the completion of the study; however, may find it challenging to remember every detail. This may result in a loss of data. Another potential disadvantage is location of the study. For example, studies that take place in a model domestic kitchen may result in participants altering their practices because they are preparing food in an unfamiliar environment. However, Redmond and Griffith (2004) found that food handling mistakes are habitual, meaning the location of meal preparation does not matter as participants will make the same mistakes regardless of location. However, other biases exist that researchers must be aware of in order to protect the reliability and validity of the study. The greatest threat to reliability is observer bias, as researchers can determine what behaviors are recorded and which ones are not based on the observer's perception. Also, the Hawthorne effect is possible wherein a participant varies their behavior because of their awareness of being videotaped or observed (Berg 2007). To overcome the Hawthorne effect many researchers employ practices such as posing as staff or not fully revealing to participants what practices are being observed.

Justification of Research

The WHO has identified five risk factors that increase the risk of contracting a foodborne illness. These include: food from unsafe sources, inadequate cooking, improper holding temperatures, cross contamination between raw and ready-to-eat products, and poor personal hygiene (i.e., handwashing) (World Health Organization 2002). Four of the five risk factors can be controlled by the food handler themselves. Therefore, the safety measures employed by consumers play an important role in the prevention of foodborne illness. However, even with proper cooking, cross contamination is a significant issue and manufacturers should consider decreasing pathogen loads before the product is brought into the home or food service.

Manufacturers can achieve this by fully cooking the products containing raw poultry or by other means such as irradiation (Weise 2008).

There is a lack of research examining whether safe food handling labels perceived as effective translate into safe food handling behaviors. Three behaviors, if used each time meat and poultry are prepared, can lower the risk of foodborne illness. These include: the use of proper thawing and cooking techniques, the use of measures to minimize cross-contamination, and the use of a food thermometer to confirm a safe final temperature has been achieved throughout the product. Furthermore, researchers have suggested a need to examine if food handlers actually do as they report they do (Jay et al. 1999; Anderson et al. 2004; Kendall et al. 2004; Weise 2008).

A limited amount of research has focused on consumers' preparation practices of frozen food entrées. This dissertation is centered on the increasing trend of consumers purchasing NRTE frozen entrées and foodborne disease outbreaks associated with such products. Currently, U.S. consumers purchase as least six frozen meals a month (McKenna 2009). While much is known about production and distribution of frozen food during processing and retailing (Terpstra et al. 2005), less is known about actual food handling and preparation behaviors after food is purchased by the consumer. This project aimed to evaluate consumers' preparation practices of raw, breaded NRTE chicken entrées, validate on-package label instructions, and evaluate product availability in grocery stores.

Prior to the commencement of the project, grocery stores were surveyed to identify products available and determine characteristics that could potentially lead to an increase risk of foodborne illness being associated with raw, prebrowned NRTE chicken entrées.

A number of issues were recognized including:

- raw and fully cooked products were shelved next to each other in the retail display case;
- manufacturers choosing to market products that were raw in packaging similar to the fully cooked version of the product;
- existing cooking instructions were potentially confusing;
- cooking instructions only available on the principal display of the packaging and not available when removed from the original packaging;
- instructions did not convey to consumers the appropriate means of cooking the product; and
- statements that encourage thermometer use blended in with other wording.

The preliminary observations in combination with the history of outbreaks provide justification that a problem do exist and further investigation was necessary.

Objectives of the Research

This project was divided into three phases, each with individual objectives:

- Create a representative list of cooking instructions on NRTE frozen breaded poultry product packaging present at the time the study was initiated,
- Examine the level of consumer understanding of food handling instructions available on products being studied, and
- Validate if on-package cooking instructions at the time of the study ensure a safe end-product if performed accurately by the consumer.

Collectively, these objectives aimed to provide a better understanding of consumers' food handling behaviors when preparing raw, frozen, breaded chicken entrées and determine if available label instructions, if followed correctly, resulted in a safe end product.

This project is unique in that it combines both qualitative and quantitative science to understand food safety risks. It contributes to the understanding of consumer behavior in response to product labeling for processed meat and poultry. The strength of the project lies in combining laboratory-based validation of common consumer cooking methods with consumer behavioral observations. In doing so, this allows for the determination of risk factors that are potentially associated with unclear or misinterpreted package labeling. Additionally, the results of this project provide processors information about the efficacy of their label cooking instructions and the extent to which they provide a safe consumer end product.

Chapter 2: Self-reported and Observed Behavior during the Preparation of Frozen, Uncooked, Breaded Chicken Entrées

Introduction

An estimated 48 million illnesses are attributed to the consumption of contaminated food each year in the USA (Scharff 2012). Reduction in foodborne illness can be accomplished through consumers making an effort to improve their safe food handling practices. Many bacterial pathogens, such as *Salmonella* spp., are commonly associated with raw foods that are prepared in the domestic kitchen on a regular basis (Redmond and Griffith 2003b).

Microwave ovens can be found in greater than 90 percent of U.S. homes (United States Department of Agriculture-Food Safety and Inspection Service 2006b). The convenience of the microwave, in combination with a wide variety of microwavable products being produced by the frozen food industry, has made microwave cooking a consumer staple. A number of ready-to-eat (RTE) and not-ready-to-eat (NRTE) breaded poultry products are available to consumers. RTE products are fully cooked by the manufacturer and only require reheating by consumers. In contrast, NRTE products are manufactured containing one or more ingredients that are not fully cooked (Food Safety and Inspection Service 2006b).

The increase in popularity of convenience foods has in turn led to an unexpected increase in foodborne illness outbreaks associated with NRTE frozen entrées. Since 1998, there have been 103 confirmed cases of salmonellosis worldwide due to eating undercooked, frozen, breaded poultry products (Kenny et al. 1999; Smith et al. 1999; MacDougall et al. 2004; Medus 2006a; Medus 2006b). Outbreaks in 2005-2006 included 30 cases of salmonellosis linked to eating frozen, pre-browned, single-serving, microwavable stuffed chicken products prepared in the home. The products' cooked appearance and label instructions may have led consumers to believe they were fully cooked (Medus 2006a). Individuals with confirmed cases of salmonellosis in these outbreaks reported not taking a final temperature reading prior to consuming the products despite statements to do so on the product packaging (Medus 2006a; Medus 2006b).

After the 2005-2006 outbreaks, the United States Department of Agriculture's Food Safety and Inspection Service (USDA-FSIS) advised processors to modify the package label on uncooked pre-browned poultry products (United States Department of Agriculture-Food Safety and Inspection Service 2006a). Products affected by the modifications included chicken nuggets, chicken strips, chicken fritters, and stuffed chicken entrées—all products implicated in previous outbreaks. In addition, a safe minimum internal temperature of 165°F or higher must be achieved as measured by a food thermometer, and the label must relay this information to the consumer (Heller 2007). Despite these label changes, four cases of salmonellosis were linked to eating undercooked, breaded poultry products in March 2008 (United States Department of Agriculture-Food Safety and Inspection Service 2008).

The current study was completed in two separate phases. The initial phase sought to establish a comprehensive inventory of available cooking instructions on NRTE breaded poultry entrées in retail and identify risk factors that may lead to an increase chance of foodborne illness when consumers prepare NRTE products. The second phase, the observational study, observed the preparation practices of both adult and young consumers preparing frozen, uncooked, breaded chicken products, which have been previously linked to consumer mishandling. The study sought, through video observation and self-report surveys, to determine if differences exist between consumers' intent and actual behavior. A limited number of studies have evaluated how food is stored, prepared, and consumed in the home (Fein et al. 1995; Altekruse et al. 1996; Anderson et al. 2004). Over the past 31 years, the most frequent method utilized by researchers for consumer food safety has been through surveys (i.e. interviews and self-completion surveys) (Redmond and Griffith 2003b). Survey methods are commonly used to assess consumers' intended food safety behaviors (Redmond and Griffith 2003b). However, there is a lack of research examining whether a consumer's intent—when provided with frozen, uncooked, breaded chicken entrées and respective product instructions—translates into actual safe food handling behavior. Clayton et al. (2003) suggest that intentions to perform safe food handling are not always manifested, as some actions taken during meal preparation are not under volitional control. Direct observation can be used to capture an individual's actual behavior and place the behavior in context (Gittelsohn et al. 1997). Video observation is often used to minimize the presence of researchers that may affect consumer behavior. The small number of studies conducted involving observation of consumer food handling behaviors through the use of video have found consumers make food handling errors during food preparation (Worsfold and Griffith 1997; Jay et al. 1999; Scott 1999; Redmond and Griffith 2003b; Kendall et al. 2004; Redmond and Griffith 2004a; Redmond and Griffith 2004b; Anderson et al. 2004). Comparison of self-reported behaviors and actual practices is particularly important for products which have been previously implicated in outbreaks where improper consumer handling was found to be the cause.

The current study also sought to observe behaviors of adolescents as home food preparers. Consumer food handling practices may vary between individuals of different sociodemographics. This unique group has not been studied in previous observational research, though food-handling behaviors of these individuals are of interest in the effort to reduce improper food handling of frozen, uncooked, breaded poultry products. Products such as chicken nuggets and chicken strips are popular among this age group.

Finally, the study aimed to compare actual food handler behaviors with those specified detailed on the product label. A survey of consumer reactions to safe food handling labels on raw meat and poultry suggested that instructions for safe handling found on labels had only limited influence on consumer practices (Yang 2000). The labels studied by this group were found on packaging of chicken products examined in the current study alongside step-by-step cooking instructions. Observational techniques, when used to investigate consumer adherence to instructions provided on packaging of foods implicated in foodborne outbreaks, will aid in the discussion of how to reduce the incidence of illness in consumer-prepared frozen, uncooked, breaded chicken products and other frozen meals.

Methodology

Pre-observational survey of NRTE poultry products in retail

Fifteen grocery stores representing nine national chains in Northeast Kansas were surveyed for frozen, uncooked, pre-browned chicken entrées from June 2006 to April 2009. Frozen food sections were surveyed for any product that may be raw, frozen, and breaded. Provided information on both the principal display panel and back panel were documented. Common products found within this category were chicken nuggets, chicken strips or tenderloins, stuffed/filled chicken entrées, and chicken pot pies—all of which have been implicated in previous outbreaks.

Overview of observational study

Participants were video-recorded while preparing a meal centered upon uncooked, frozen, breaded chicken products in a model kitchen at Kansas State University in Manhattan, Kansas, U.S. Following meal preparation, participants were asked to complete a written survey about the meal they had prepared and their typical experiences with meal preparation at home. The videos were later used to create data characterizing participants' behaviors. On average, the food preparation session lasted an hour. However, time involvement was dependent on the product prepared, the cooking appliance selected by the participant, and the steps taken (number and speed of action) by each participant.

Sample

The two consumer groups studied were adolescents and primary meal preparers, defined, respectively, as children 12 to 14 years of age (Centers for Disease Control and Prevention 2005a) and those who prepare food in the home at least twice a week (Clayton et al. 2003). A convenience sample was used for participant selection. Adolescents and their parents from two area youth basketball teams were recruited for participation after initial attempts to recruit participants using advertisements (Internet listings and flyers in local media—Appendix A) were abandoned due to a low response rate. A small sample size was selected to accommodate the limited space available for observations. In order to minimize participant reactivity, the study was advertised as a food quality study rather than a food safety study. A total of 41 individuals participated; 21 primary meal preparers (3 males/18 females) and 20 adolescents (10 males/10 females). Each participant received $25 USD and a t-shirt following participation.

The Kansas State University Institutional Review Board approved this study and all study participants signed informed consent forms prior to participating.

Tools/equipment for observation

All food preparation observations were conducted in one of two model kitchens at Kansas State University. The kitchens were selected from 10 available units designed for use as student food preparation kitchens. The two study kitchens had slightly different layouts, but pilot testing showed that these differences were not significant enough to impact the flow of food preparation. Three small surveillance cameras (QuickCam Pro 5000, Logitech) were strategically secured within each kitchen to capture the participant's food preparation practices from all angles (Appendix B). A camera viewing the stove, one viewing the sink, and another viewing the length of the countertop, recorded each participant's actions. A schematic of the model kitchens is provided in Figure 2.1 (Meredith et al. 2001); arrows denote the angle of each cameras view.

The food products for the study—uncooked, frozen, breaded, chicken entrées (chicken strips and chicken kievs) and pre-chopped salad ingredients for a salad (bagged lettuce, tomatoes, carrots, cucumbers, and salad dressing)—were purchased from a local supermarket in June, 2007. A number generator was used to randomly assign one of the two frozen, uncooked, breaded chicken entrées for each participant to prepare.

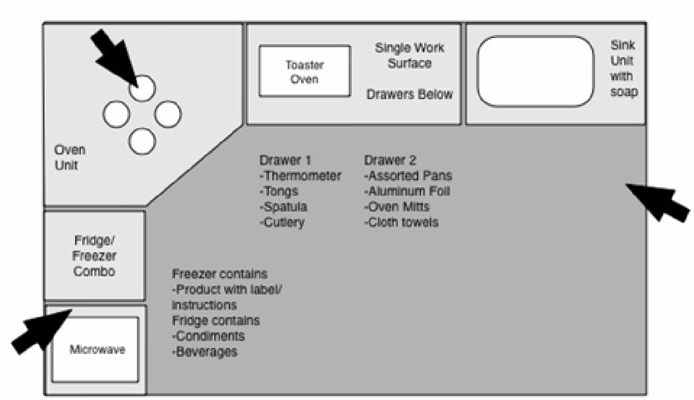


Figure 2.1: Schematic diagram of model kitchen

Prior to the arrival of each participant, the randomly assigned chicken entrée was placed in the participant's freezer in its original packaging. A copy of each product's label instructions can be found in Table 2.1.

Additionally, three plastic containers containing precut vegetables were placed in the refrigerator along with bagged lettuce and salad dressing. Each kitchen contained five appliances available for use by the participant—a conventional oven, a microwave oven, a toaster oven, a range top and frying pan, and a deep fat fryer. All kitchens were equipped with utensils—including assorted pans, splatter guard, serving dishes, cutlery, tongs, food thermometers (one dial instant read and one digital), timer, oven mitts, wash rags, dish towels and paper towels. Clorox disinfecting kitchen cleaner, Lysol disinfecting wipes, dish soap, sponge, hand soap, and hand sanitizer were placed in the cabinet below the sink in each kitchen. Two pilot studies were carried out to finalize the camera placement, the script of instructions to participants, and significant differences in kitchen layout prior to the observation of the 41 participants.

Table 2.1: Product label instructions provided to participants

Chicken Kievs
COOKING INSTRUCTIONS (This RAW PRODUCT must be thoroughly cooked). "THIS IS A RAW PRODUCT THAT MUST BE FULLY COOKED." We recommend: Always cook to at least 165F. Always use a food thermometer, checking ALL final portion's temperatures in several places. When fully cooked, breast meat, will be white NOT pink in color. These instructions are only a guide. Variations in time and temperature may be required for variation in appliances or for variations in portion sizes or portion quantities cooked."
CONVENTIONAL OVENS (Recommended for best result) – COOK FROM FROZEN: Bake 1-2 unwrapped portions in a shallow pan for 30-35 minutes in a PREHEATED oven at 400F. May need to increase cook time for extra portions.
MICROWAVE OVENS – COOK FROM FROZEN (based on 1000 watts of power): Cook on a microwave-safe plate with microwave-safe covering. Cook 1 unwrapped portion for 2 minutes. Turn the piece over and cook for 2 minutes more. For 2 pieces, increase each step by 1 1/2 minutes with spacing between pieces. Do not microwave cook more than 2 pieces at once.
Chicken Strips
HEATING INSTRUCTIONS: We recommend frying for the most authentic homestyle flavor.
DEEP FRY: Preheat oil to 350F. Fry frozen filets for approximately 4 to 6 minutes (until they float). Mini-fryers may take longer.
PAN FRY: Preheat 1/4 inch oil in skillet using medium heat. Fry frozen filets 5 to 7 minutes. Turn once halfway through cooking time.
CONVENTIONAL OVEN: Preheat oven to 450. Place frozen filets on cookie sheet and bake for 23 to 25 minutes. Turn once about halfway through cooking time.
MICROWAVE INSTRUCTIONS: The following instructions were from a 600 Watt oven with the power setting on HIGH. Cooking times will vary with oven wattage and power levels. Place a single layer of frozen filets on a dish and heat uncovered on HIGH. 1 filet – 5 minutes 2 filets – 6 minutes 3 filets – 7 minutes Turn filets over and rotate dish halfway through cooking. Let stand 2-3 minutes before serving. If more than 3 filets are desired, divide into two separate heatings for best results. Note: To ensure fully cooked product, make sure the thickest part of the filet is white in color and is at an internal temperature of 165 F when using a food thermometer.

Instructions to participants

At the start of each session, a trained researcher provided a brief overview of the kitchen and its contents to each participant. The environment constructed for participant food preparation was designed such that practices observed in model kitchens would be representative of behaviors used at home. Participants were invited to spend time (approximately five minutes) familiarizing themselves with the kitchen. During the introduction, participants were asked to prepare the assigned entrée and a side salad for three individuals using the provided ingredients as they would in their own home. Reading materials and snacks were made available to the participants who chose to leave the kitchen while waiting for the cooking process to be completed. For food safety reasons, the participants were not allowed to consume the meal they prepared and were asked to inform a research assistant when they felt the product being prepared was ready to consume. Participants in the study were observed on an individual basis and had no interaction with participants while they completed the food study.

Survey

Each participant completed at 24-question self-report survey after completion of the food preparation. The survey was given after completion of each food preparation session -- and not before, so as to not prompt participants about microbial food safety before their meal preparation session. Questions for the survey were adapted from previous food safety-based studies (Woodburn and Raab 1997; Jay et al. 1999; Haapala and Probart 2004; Kendall et al. 2004; McCurdy et al. 2006 ; Anderson et al. 2004). A consumer's intention is determined by a combination of an individual's attitude toward performing a specific behavior (i.e. behaviors that will prevent and protect them from foodborne illness) and their subjective norms (Ajzen and Fishbein 1980), which can be established by the belief that relevant others approve or disapprove of the specific behavior or the individual's motivation to comply with relevant others. The main objectives of the written survey were to 1) evaluate participants' awareness of foodborne illness; 2) determine their frequency of purchasing, preparing, and consumption of uncooked, breaded chicken products in the home; 3) establish ownership and reported frequency of use of food thermometers; and 4) determine the participants' reported handwashing behaviors.

The questionnaire was pre-tested with ten individuals of the general public with minimal food safety knowledge to provide feedback regarding language appropriateness and format. The final instrument consisted of a variety of question types including: short answer, multiple choice, Likert-scale, ordinal, dichotomous response, and demographic. The survey took approximately ten minutes to complete (Appendix C).

Coding behaviors

After all observation video sessions were completed (n=41), codes were assigned to participant behaviors to create research data. A detailed observation checklist

(Appendix D) based upon the U.S. Centers for Disease Control and Prevention's identified risk factors for foodborne illness (Bean et al. 1996) tracked the following behaviors: handwashing, avoiding cross-contamination, determining doneness of the chicken product, food thermometer use, and reading and applying product label instructions.

A coding scheme of correct, incorrect, or not performed was used by two trained research assistant for most behaviors. This first scheme was applied to behaviors for which a correct practice was defined (e.g. properly cleaning a food thermometer after use was defined as rinsing with water and wiping with a towel). A second scheme was applied to behaviors for which correct behavior could not be defined or determined (e.g. whether the participant did or did not use an appliance for which the label provided cooking instructions). These remaining behaviors were coded as either yes (i.e. observed) or no (i.e. not observed) (Appendix E). Percent agreement for each behavior was calculated by dividing the number of times agreed on the specific behavior by the total number of observations (Babbie 2006). In circumstances in which an agreement could not be reached by the two research assistants, a third research assistant was trained to recode those specific behaviors.

To establish inter-coder reliability, the two research assistants simultaneously watched and coded video of the first participant. Any differences identified by comparing resulting codes were discussed between the two coders and consensus was reached. Video of the second participant was coded in the same manner to further improve the uniformity of the data collected. Similar methods have been reported in the literature (Jay et al. 1999; Anderson et al. 2004; Kendall et al. 2004). Each research assistant viewed the remaining videos independently and codes were assigned to the behaviors to create research data.

Data analysis

The observation and survey data were analyzed for descriptive statistics. Internal consistency for Likert scale items was assessed using Cronbach alpha values. All values were calculated using the Statistical Package for the Social Sciences (SPSS Inc, Version 15, Chicago, IL).

Results

Pre-observational survey of retail for NRTE entrées

At the commencement of the study in June 2006, 30 NRTE frozen breaded poultry products were identified as microwavable. However, due to the multiple cases of salmonellosis linked to breaded NRTE poultry entrées and resultant media coverage and USDA-FSIS actions, only 18 products remained available to consumers in the surveyed area at the completion of the study in April 2009. Table 2.2 details common instructions/warning statements found on the some of the identified products. The 2005-2006 outbreak in Minnesota and 9 other states in which 41 individuals fell ill from

Table 2.2: Products found in retail in northeast Kansas in April 2009

Product	Principal Display	Cooking Instructions	Grocery Chain
Chicken Cordon Bleu	Keep frozen, raw product, cook to an internal temperature of 165°F as measured by a thermometer.	This raw product must be cooked thoroughly. Cook in Conventional Oven only. Cook 1-4 portions for 30-35 minutes. May need to increase cook time for extra portions.	Grocery Chain A
Chicken Breast Strips	Uncooked: For safety must be cooked to an internal temperature of 165°F as measured by a food thermometer.	Bake uncovered, for 25-30 minutes, turning strips over after 12 minutes, or until an internal temperature reaches 165°F	Grocery Chain A
Chicken Breast Filets	No Information	Cooking times will vary with microwave wattage and power levels. Place a single layer of frozen filets on a dish and heat uncovered on HIGH (1 filet: 5 minutes; 2 filets: 6 minutes; 3 filets: 7 minutes). Let stand 2 -3 minutes before serving. NOTE: to ensure fully cooked products, make sure the thickest part of the filet is white in color and has an internal temperature of 165°F when using a food thermometer.	Grocery Chain B
Chicken Cordon Bleu	Ready To Cook: Uncooked: for safety, product must be cooked to an internal temperature of 165°F as measured by a thermometer.	Microwave Instructions: Place breast upside down on microwave safe plate and cook on HIGH: 1 breast for 2 minutes, 2 breasts for 3 minutes, turn breast over and cook on HIGH: 1 breast for 3 to 4 additional minutes, 2 breasts for 5 to 6 additional minutes. Let stand 2 to 3 minutes before serving. Preferred method is the oven.	Grocery Chain C
Chicken with Broccoli & Cheese	Uncooked, Keep frozen, cook to an internal temperature of 165°F as measured by a food thermometer.	DO NOT MICROWAVE. PRODUCT IS RAW. Cook to 165°F. Use a food thermometer, checking each portion's final temperature in several places. Portion's internal temperature must be at least 165°F.	Grocery Chain D
Chicken Breast Filets	Uncooked; Cook To 170°F	For food safety, must be cooked to an internal temperature of 170°F, check with thermometer. When fully cooked, breast meat will be white, NOT pink in color.	Grocery Chain D
Chicken Breast Strip Fritters	Uncooked: For food safety, must be cooked to 165°F as measured by use of a thermometer.	From Frozen: Deep Fry at 350°F for 4 - 5 minutes to fully cook. Appliances vary. Adjust cooking times accordingly.	Grocery Chain E

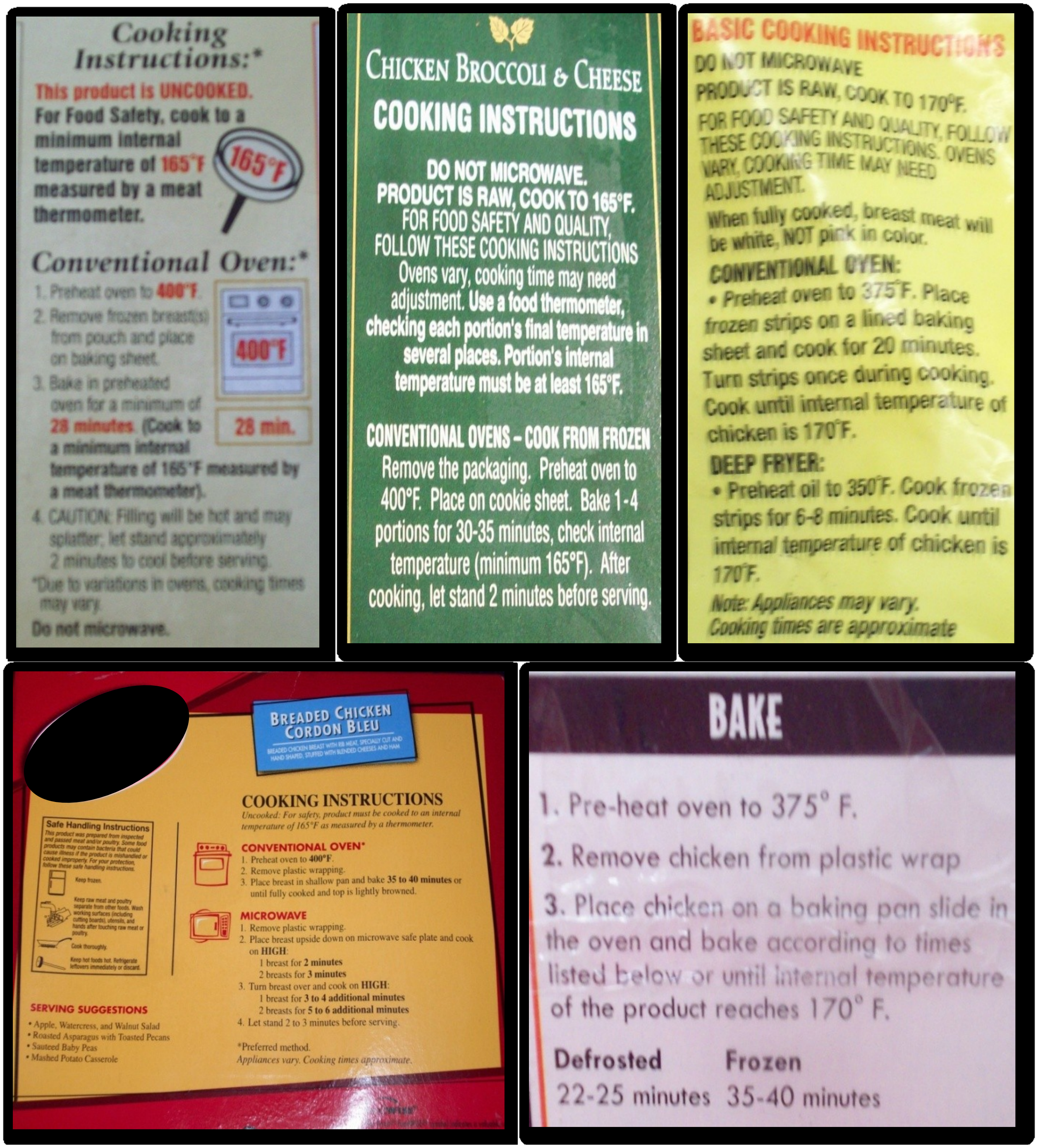


Figure 2.2: Examples of cooking instructions found on NRTE breaded poultry products found in retail 2009

salmonellosis after eating an undercooked stuffed chicken entrée forced processors to reevaluate their microwave cooking instructions. For the microwave to remain as an acceptable method of preparation, the instructions on labels must be validated (Food Safety and Inspection Service 2006b). There are many variables (difference in wattage, power, products prepared, etc.) to consider when validating microwave cooking instructions. Unsuccessful attempts to validate the instructions led to most processors removing the instructions. Acceptable preparation methods listed for the entrées are now the conventional oven and deep frying. Figure 2.2 provides a snapshot of instructions on product packaging from 2006 to 2009.

Entrées that formerly were labeled as microwavable now include the statement "DO NOT MICROWAVE." Some processors removed the microwave as an acceptable means of preparation from the label, but chose not to include a warning statement discouraging cooking in a microwave oven.

Frozen Food Product Display

All grocery stores surveyed contained two different types of display cases for frozen food. The first, an upright display case, contained all poultry products regardless of their cooked nature. In this circumstance, fully cooked products were often placed directly next to raw products (Figure 2.3). The second, a floor display case, had both fully cooked and uncooked products within the same case. On two separate visits to a single grocery chain, products were not separated based on their cooked nature, but haphazardly thrown into the display case. Furthermore, in one national chain uncooked stuffed chicken entrées were found buried beneath fully cooked products that at one time had been stored separated. Improper consumer food handling could be influenced

Figure 2.3: Fully cooked and uncooked entrées positioned in the same display case

by the placement of raw and cooked products in close proximity within the same display, by the vagueness of the label not clearly identifying the cooked nature of the product, or by consumers lacking the awareness that a difference exists between raw and fully cooked entrées. Grocery stores should maintain a clear separation of raw and fully cooked products because a hurried consumer, while shopping, could potentially grab a product they believe to be fully cooked, but in fact is raw. As a result of the grocery store failing to keep distinct separation, a consumer could proceed to cook the entrée as if it was a fully cooked product because it was housed with other fully cooked entrées.

Principal display panel

Both fully cooked and uncooked pre-browned chicken entrées are available to consumers at retail. Initial accounts of previous outbreaks linked to NRTE entrées have suggested that cooking instructions may have been unclear or misleading or confusing, resulting in consumers undercooking the entrées. While processors view RTE and NRTE products as completely different, consumers may not understand the difference between the entrées. The principal display and the back panel both contain important information for consumers. The principal display is the portion of the package that is most likely to be seen by consumers at the time of purchase and should bear prominent and clear terms that convey the cooked nature of the product. Both fully cooked and raw products were observed to have similar packaging, but the wording found on the principal display differed between products. Figure 2.4 illustrates RTE and NRTE versions of stuffed entrées being marketed in a similar packaging and in close proximity in the display case. Prior to the 2005-2006 outbreak linked to uncooked, stuffed, pre-browned breaded chicken entrées, both RTE and NRTE products were packaged within a red box containing a picture of a Cordon Bleu (Figure 2.4). On the principal display panel, the fully cooked version prominently displayed the statement “heat and serve” while the package of the raw product indicated, “cook thoroughly” or “ready to cook” in the lower right hand corner. Following the 2005-2006, the raw product was found within a golden brown package while the fully cooked product remained in a red box.

Figure 2.4: Similar packaging for NRTE and RTE stuffed chicken entrées from a single manufacturer

In addition to the color change, the wording on both packages had also been altered. A caution statement was included on the raw product encouraging consumers to measure the internal product temperature with a meat thermometer. The statement is put on the principal display for a reason—to remind the consumer that the product was raw and must be fully cooked prior to consuming the entrée. Processors have added a "fully cooked" sticker to the principal display of the fully cooked product, advertising the product as microwavable and ready in just 5 minutes.

The back panel of the package of all products surveyed contained the suggested cooking methods. The most common method listed on the cooking instructions was the conventional oven, as it provides more uniform cooking compared to other methods. A key statement listed separate from the cooking instructions stated on all products, "ovens vary, cooking times may need adjustment." This statement is meant to convey to consumers that not all appliances cook at the same rate, thereby, suggesting that even if one follows the listed cooking instructions the end result may not be a fully cooked product. Therefore, it is up to the consumer to determine what length of time is needed to ensure a safe end product. However, this statement was not bolded and blends in with the other text found on the product's packaging.

Following the completion of the study, one manufacturer revamped their packaging of uncooked stuffed chicken entrées. The products were originally individually packaged and housed within a cardboard box printed with the recommended cooking and handling instructions. The packaging of their products is now in individual clear packaging (Figure 2.5—right side). Approximately 30 entrées were housed in a cardboard sleeve mimicking packaging of other microwavable entrées (i.e. burritos). The product was not shelved with other raw chicken entrées, but across

Figure 2.5: Alterations in product packaging

the aisle in a separate display case along with other raw entrées intended for microwaving. The instructions had also been slightly altered. In addition, diagrams of an oven, microwave, and thermometer now appeared on the instruction panel of the

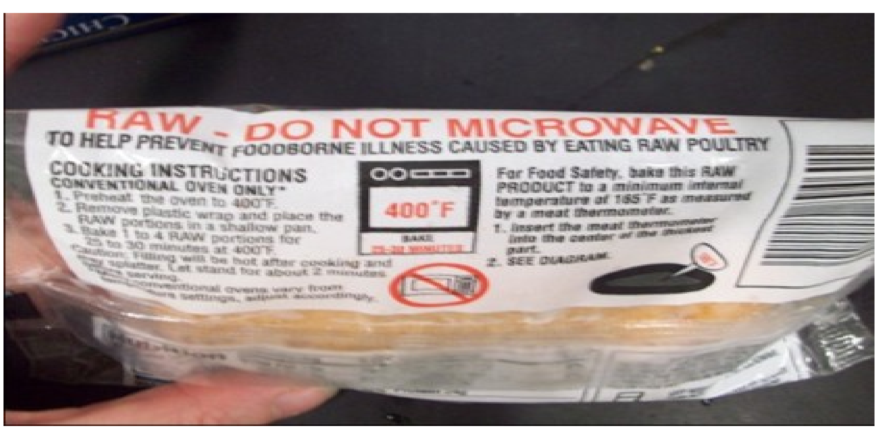


Figure 2.6: Product label illustrating microwave cooking is prohibited

product. The instructions stated to cook the product only in a conventional oven. The processor provides a picture of a microwave with a prohibited sign over the image (Figure 2.6). The processor is using this approach to convey to consumers that microwaving this entrée is not an acceptable method of preparation.

Cooking instructions

A contributing factor identified in all outbreaks linked to NRTE breaded poultry products has been labels that confuse consumers. Outbreaks of salmonellosis in 2007 associated with chicken pot pies manufactured by ConAgra highlighted the need for clearer cooking instructions on product packaging. ConAgra claimed that current label instructions were designed to eliminate the presence of common foodborne pathogens and believed consumers should know that cooking times will vary depending on the wattage of the microwave. Dr. Michael T. Osterholm, Director of the Center of Infectious Disease Research and Policy at the University of Minnesota, argued manufacturers were placing too much responsibility on consumers. He explained, "I do not believe that it is fair to put this responsibility on the back of the consumer, when there is substantial confusion about what it means to prepare the product" (Moss 2009). Manufacturers of NRTE products expect consumers to follow the provided cooking instructions and use a food thermometer to check the internal temperature; however, the chicken pot pies lacked clear cooking instructions. The principal display of the package bore the claim, "Ready in 4 minutes: microwavable." While appealing to the rushed consumer, the statement was not accurate. The actual cooking instructions advised consumers to cook the pot pie for 4 minutes if using medium or high wattage microwaves, but an additional two minutes was required if using a low wattage microwave. In addition, no guidance was given on how to determine the wattage of the microwave. Consumers were also instructed to let the product stand for three minutes following a four or six minute cook time. Therefore, the product was actually ready to be consumed after seven minutes or nine minutes (depending on wattage used) not the four minutes as advertised. Following the outbreak, "Microwavable: Must Be Cooked Thoroughly" replaced "Ready in 4 minutes: microwavable." In addition to the wording change on the principal display, the instructions were altered to read: "Do not cook in ovens below 1100W, as pot pie may not cook thoroughly." In limiting the wattage of the microwave in which the product should be prepared, the manufacturer puts the responsibility on the consumer to know the wattage of their microwave. In fact, an informal review of local appliance retailers and websites showed a high popularity of microwave ovens with wattages ≤1000. This also assumes consumers read the fine print on the label which gives the consumer additional information about preparing the product.

While most NRTE products cooked in the microwave are quick and easy because of short cooking times, the instructions for other NRTE products, such as a stuffed entrée, are equally as detailed and time consuming as the pot pie. When cooking a stuffed chicken entrée in the microwave, a consumer cannot simply enter in the cooking time and walk away. A consumer is instructed to place the stuffed entrée upside down on a microwave safe plate and cook on HIGH for 2 minutes; turn the breast over and heat on HIGH for 1 to 2 minutes; rotate and heat on HIGH an additional minute; and then let stand for 3 minutes before consuming. Instead of following the step-by-step instructions provided, a consumer may choose to enter in a single cooking time of five minutes. Microwaves heat unevenly and can leave cold spots in the food that could potentially harbor dangerous pathogens. In flipping the product during cooking, it is expected that the product receives a more uniform exposure to heat.

Observational Study

Participants

The mean age for primary meal preparers and adolescents participating in this study were 40.3 ± 8.9 SD (range 25 to 55) years and 12.9 ± 0.6 SD (range 12 to 14) years, respectively. The majority of participants was female (68.3 percent), Caucasian (90.2 percent), spent less than 10 hours on weekly food preparation (73.2 percent), and reported never having received any formal food safety training prior to participation. Approximately 73 percent of participants felt they were unlikely to get food poisoning from food prepared in the home. Additionally, 85 percent felt it was unlikely to contract food poisoning as a result of their personal food preparation practices. Most participants (68 percent) did not believe any member of their household—including themselves—had experienced food poisoning in the past year. The majority of participants (58.5 percent) reported having purchased the same breaded chicken product prepared in the study prior to participating. When asked to indicate whether the breaded chicken was raw or fully cooked, 12.2 percent reported purchasing raw products, 39.0 percent reportedly purchased products that were fully cooked, and 48.8 percent did not know.

Handwashing

In post-preparation surveys, 90 percent of primary meal preparers reported washing hands both prior to beginning food preparation and after every occasion where raw poultry was handled. This was contradicted by observational data found in Table 2.3. The table outlines a total of six instances in which handwashing was advisable to prevent foodborne illness during the meal preparation observed in this study. Almost half (47.6 percent) failed to wash their hands correctly after handling the raw poultry product. Correct handwashing was defined as using soap and running water at any temperature for any length of time. Handwashing methods considered incorrect were inadvertently washing hands as part of washing dishes or rinsing hands with water only. Similar to the primary meal preparers, the majority of adolescents reported washing their hands prior to beginning food preparation (90.5 percent) and after handling the raw poultry product (85 percent). In contrast to their reported behaviors, only half of adolescents (55 percent) correctly washed their hands before preparing food for the first time and most (90 percent) made no attempt to wash their hands after handling the raw product. Common instances in which both groups failed to wash their hands when it would be advisable were after handling raw product packaging, after touching the face and the body, and after reentering the room in which the meal was being prepared.

Avoiding cross-contamination

Nearly all participants behaved in a manner that could potentially lead to cross-contamination, either directly or indirectly, from the raw, breaded chicken product. Instances of cross-contamination were higher in adolescents compared to primary meal preparers (Table 2.4). After contacting the raw products, adolescents commonly made indirect transfers by touching the refrigerator door handle (90 percent), touching the cooking appliance (80 percent), handling the dishes used for serving (80 percent), touching the counters (70 percent), opening drawers (60 percent), and finally, using utensils and touching other parts of their body (45 percent). The average number of potential cross-contamination events, both directly and indirectly, ranged from 2.8 to 4.6 times for all participants.

Determining doneness of the chicken product

Nearly half (42.5 percent) of participants reported knowing the suggested end temperature for cooking poultry to ensure doneness. When asked the final

Table 2.3: Observed instances of handwashing among primary meal preparers and adolescents during meal preparation using frozen, raw breaded chicken entrées

Primary Meal Preparers (n=21)				
Behavior	No. Correct (%)	No. Incorrect (%)	Behavior Not Performed (%)	Avg. time spent washing hands (seconds)
Individual washed hands before beginning product preparation	19 (90.5)	2 (9.5)	--	**15.9**
Individual washed hands after handling product packaging	4 (19.0)	16 (76.2)	1 (4.8)	**15.2**
Individual washed hands after handling raw product	10 (47.6)	6 (28.6)	5 (23.8)	**11.1**
Individual washed hands before handling cooked product	1 (4.8)	3 (14.3)	17 (81.0)	**11.0**
Individual washed hands after reentering the kitchen	8 (38.1)	8 (38.1)	5 (23.8)	**13.0**
Individual washed their hands after contact with mouth and/or nose	1 (4.8)	7 (33.3)	13 (61.9)	**15.0**
Adolescents (n=20)				
Behavior	No. Correct (%)	No. Incorrect (%)	Behavior Not Performed (%)	Avg. time spent washing hands (seconds)
Individual washed hands before beginning product preparation	11 (55.0)	9 (45.0)	--	**18.0**
Individual washed hands after handling product packaging	2 (10.0)	18 (90.0)	--	**28.0**
Individual washed hands after handling raw product	0 (0.0)	18 (90.0)	2 (10.0)	**--**
Individual washed hands before handling cooked product	2 (10.0)	13 (65.0)	5 (25.0)	**6.0**
Individual washed hands after reentering the kitchen	1 (5.0)	10 (50.0)	9 (45.0)	**11.0**
Individual washed their hands after contact with mouth and/or nose	**0 (0.0)**	**9 (45.0)**	**11 (55.0)**	**--**

Table 2.4: Instances of cross-contamination during meal preparation using frozen, raw breaded chicken entrées

Primary Meal Preparers (n=21)				
Behavior	Yes (%)	No (%)	Behavior Not Performed (%)	Avg. number of instances
Individual touch other surfaces after handling the raw product and not washing hands	11 (52.4)	9 (42.9)	1 (4.8)	--
Individual touched the cooking appliance	10 (47.6)	2 (9.5)	9 (42.9)	3.0
Individual touched the refrigerator	7 (33.3)	4 (19.0)	10 (47.6)	2.3
Individual touched the utensils used for cooking	3 (14.3)	8 (38.1)	10 (47.6)	1.7
Individual touched the dishes used for serving	6 (28.6)	5 (23.8)	10 (47.6)	3.7
Individual touched any part of their body	2 (9.5)	9 (42.9)	10 (47.6)	2.5
Individual touched the counters	4 (19.0)	7 (33.3)	10 (47.6)	2.3
Individual touched the drawers	3 (14.3)	8 (38.1)	10 (47.6)	4.7
Individual used the same utensils to handle the raw and fully cooked product w/o washing	7 (33.3)	12 (57.1)	2 (9.5)	--
Adolescents (n=20)				
Behavior	Yes (%)	No (%)	Behavior Not Performed (%)	Avg. number of instances
Individual touched other surfaces after handling the raw product and not washing hands	18 (90.0)	2 (10.0)	--	--
Individual touched the cooking appliance	16 (80.0)	2 (10.0)	2 (10.0)	4.0
Individual touched the refrigerator	18 (90.0)	--	2 (10.0)	2.8
Individual touched the utensils used for cooking	9 (45.0)	9 (45.0)	2 (10.0)	3.0
Individual touched the dishes used for serving	16 (80.0)	2 (10.0)	2 (10.0)	3.4
Individual touch any part of their body	9 (45.0)	9 (45.0)	2 (10.0)	3.3
Individual touched the counters	14 (70.0)	4 (20.0)	2 (10.0)	4.6
Individual touched the drawers	12 (60.0)	6 (30.0)	2 (10.0)	3.2
Individual used the same utensils to handle the raw and fully cooked product w/o washing	**5 (25.0)**	15 (75.0)	**--**	--

recommended internal temperature for chicken, the mean response was 214°F with a range of responses from 140°F to 450°F. Table 2.5 outlines a variety of actions taken by participants before the chicken product was served to presumably determine if the product was fully cooked.

Table 2.5: Determining doneness of the final product

Primary Meal Preparers (n=21)	
Method	**Number of participants (%)**
No attempt was made	10 (47.6)
External appearance of product	8 (38.1)
Thermometer	2 (9.5)
Poked with a utensil	1 (4.8)
Adolescents (n=20)	
Method	**Number of participants (%)**
No attempt was made	13 (65.0)
External appearance of product	5 (25.0)
Thermometer	1 (5.0)
Poked with a utensil	1 (5.0)

For both primary meal preparers and adolescents, virtually no attempt was made to determine product doneness. Most often, following the expiration of the appliance timer, the product was removed from the chosen cooking appliance and plated for serving. The next most common methods used were, in descending order: examining the visual appearance of the product, using a food thermometer, and poking it with a utensil. One participant was observed measuring the temperature of the product by touching it with her hand before returning it to the microwave for further heating.

Food thermometer use

Though labels on both test products instructed consumers to ensure the internal temperature of the product reached 165°F as measured by a food thermometer, only five of 41 participants used a food thermometer to determine the doneness of either chicken entrée (Table 2.6). Of all participants, 73.2 percent reported owning a digital or dial instant read food thermometer. Of those who owned a food thermometer only 4.8 percent reported using it often or always. Only a small percentage of participants (19.5 percent) reported using a food thermometer to determine the internal temperature of raw breaded chicken products in their own kitchens. However, only 12.2 percent of all participants were observed taking the internal temperature of the chicken entrée prior to plating it. Of those that checked the internal temperature of the entrée, only three used the thermometer correctly. Two of the individuals failed to remove the protective casing on the digital thermometer probe prior to insertion into the cooked product and therefore the product's internal temperature would not have been accurately recorded.

Reading and applying product label instructions

The research assistants used detailed checklists of the exact label instructions for each product when coding observed behaviors to determine if participants correctly followed the label instructions during product preparation. Table 2.7 outlines the behaviors observed for reading label instructions. Both the chicken Kiev and breaded chicken strips had similar label instructions. Most participants (90.5 percent of primary meal preparers and 90 percent of adolescents) were observed reading the product label. When asked on the survey if they noticed the label containing the cooking instructions, 90 percent recalled noticing the label instructions; only 85.4 percent of those individuals reported reading them. However, of those that read the instructions only 61 percent

Table 2.6: Food thermometer use during meal preparation using frozen, raw breaded chicken entrées

Primary Meal Preparers (n=21)			
Behavior	Correct (%)	Incorrect (%)	Behavior Not Performed
Individual was aware of the food thermometers in the kitchen	6 (28.6)	15 (71.4)	--
Individual used a food thermometer to determine the final internal temperature	4 (19.0)	17 (81.0)	--
Individual cleaned the thermometer after use	1 (4.8)	3 (14.3)	17 (81.0)
Adolescents (n=20)			
Behavior	Correct (%)	Incorrect (%)	Behavior Not Performed
Individual was aware of the food thermometers in the kitchen	1 (5.0)	19 (95.0)	--
Individual used a food thermometer to determine the final internal temperature	1 (5.0)	19 (95.0)	--
Individual cleaned the thermometer after use	1 (5.0)	0 (0.0)	19 (95.0)

Table 2.7: Reading and applying label instructions during meal preparation using raw, breaded chicken entrées

Primary Meal Preparers (n=21)				
Behavior	Yes (%)	No (%)	Avg. time spent reading instructions (seconds)	Avg. number of times instructions were read
Individual read the label instructions	19 (90.5)	2 (9.5)	--	--
Length of time individual read the instructions	--	--	22.6	--
Number of times individual read the instructions	--	--	--	2.9
Individual used an appliance listed on product label	20 (95.2)	1 (4.8)	--	--
Individual switched cooking appliances during product preparation	3 (14.3)	18 (85.7)	--	--
Individual followed the label instructions	2 (9.5)	19 (90.5)	--	--
Adolescents (n=20)				
Behavior	Yes (%)	No (%)	Avg. time spent reading instructions (seconds)	Avg. number of times instructions were read
Individual read the label instructions	18 (90.0)	2 (10.0)	--	--
Length of time individual read the instructions	--	--	21.4	--
Number of times individual read the instructions	--	--	--	3.2
Individual used an appliance listed on product label	19 (95.0)	1 (5.0)	--	--
Individual switched cooking appliances during product preparation	0 (0.0)	20 (100.0)	--	--
Individual followed the label instructions	1 (5.0)	19 (95.0)	--	--

reported that the instructions either completely or strongly influenced how they prepared the product.

Two of the five appliances provided in the model kitchens (microwave and conventional oven) were listed on the product label as an appropriate means for cooking the chicken kievs; four of the five appliances (microwave, conventional oven, pan fry, and deep fry) were listed as appropriate means for cooking breaded chicken strips. Almost all participants (95 percent) chose a cooking appliance listed on the respective product label. The two appliances chosen most often by participants for both products were the microwave oven and the conventional oven. In one situation, a participant used both of these appliances listed on the product label, though in a fashion not addressed by the label instructions: upon discovering he was pressed for time to meet another engagement, the primary meal preparer removed the products from the conventional oven in which they had been cooking and attempted to complete the cooking process in the microwave.

The primary mistakes made by individuals that chose to use the microwave were failing to use a microwave safe covering and not turning the chicken entrée half way through cooking, both suggested by the label. One participant used a convenience setting (touch key on front of microwave oven) not included in recommended cooking instructions designated "Poultry," that was a pre-set program intended to thaw poultry products, rather than to thoroughly cook them. This method was indeed inadequate to reach a microbiologically safe internal temperature though the participant assumed the product was ready for consumption. Participants choosing the conventional oven often failed to allow adequate time for the appliance to preheat, did not extend the cooking time for cooking multiple strips or kievs, and/or opened the oven door while the entrées were cooking. Oftentimes, participants who successfully allowed the appliance to preheat did so while the product waiting to be cooked remained on the countertop at room temperature, such that it was not in a completely frozen state when the cooking process began as is directed on the label instructions. The majority of participants (90.5 percent of primary meal preparers and 95 percent of adolescents) made at least one mistake during product preparation. Therefore, only 9.5 percent of primary meal preparers and 5 percent of adolescents correctly followed the entire set of product label instructions.

Discussion

Manufacturers of NRTE poultry products need to develop more effective mechanisms to convey less confusing, more standardized, and more compelling safe handling messages to a diverse population. Overall, product labels serve as a public health intervention meant to potentially prevent foodborne illness by compelling consumers to modify their personal behaviors. Processors should aim to understand why and how consumers utilize food labels prior to developing new labels. The new labels should address the critical gaps in what consumers know and what they need to know. The effectiveness of any public health intervention, such as food labels, is dependent upon the consumer's willingness to read what is being provided.

Data obtained from self-completed surveys in this study provided a positive depiction of study participants' food safety knowledge and behavior; however, observational results showed all participants implemented unsafe food handling practices that may lead to an increased risk of foodborne illness. In addition, actual observed practices varied between adolescents and primary meal preparers. Finally, information provided on produce labels did not sufficiently compel consumers to follow instructions. Consistent with previous research (Jay et al. 1999; Anderson et al. 2004; Haapala and Probart 2004; Kendall et al. 2004; McCurdy et al. 2006), a clear discrepancy was identified between direct observation and self-reported data regarding handwashing behaviors and thermometer use. Although 90 percent of primary meal preparers reported washing their hands after every instance in which hands contacted raw poultry, almost half (47.6 percent) were not observed washing hand correctly. A similar study (Anderson et al. 2004) of individuals considered main meal preparers found that 40 percent of participants who reported washing their hands with soap and water after handling raw product but before preparing a salad were not observed doing so. The authors note that meal preparers who understand the importance of handwashing will not readily admit in self-report surveys that it is not utilized.

A common mistake consumers make during food preparation is not washing their hands prior to handling food. Worsfold and Griffith (1997) and Anderson et al. (2004) found that between 34 and 38 percent of participants did not engage in handwashing before beginning meal preparation. Similarly, this study observed 27 percent of participants failing to wash their hands properly prior to beginning food preparation. Differences in the age of study participants could possibly account for slight discrepancies in statistics. Adolescents in the present study were less likely to wash their hands before meal preparation and after handling the raw product compared to primary meal preparers. Pinfold (1999) suggests that adolescents may only practice handwashing if they believe their hands to be visibly dirty, rather than washing them before or after certain activities.

Adolescents are a unique group of home food preparers, as they are likely to cook and consume products like chicken strips, yet have not been studied in previous observational research. In this study, adolescents made more mistakes during product preparation and were observed engaging more often in unsafe food handling practices. For example, several female adolescents brushed their hair from their face with contaminated hands. Many of the adolescents contaminated cabinets and drawers with unwashed hands when they searched the kitchen's contents out of boredom while waiting for the cooking process to be completed. Adolescents' failure to wash hands after handling raw product (0.0 percent) led to increased instances of direct cross-contamination compared to primary meal preparers (47.6 percent).

Many participants reported owning a food thermometer (73.2 percent) but substantially fewer reported using it when cooking raw, breaded chicken entrées (19.5 percent). During our observational study, few participants (12.2 percent) attempted to measure the final internal product temperature demonstrating again the discrepancy between self-reported and actual behavior. Participants within this study relied on inadequate techniques to estimate their chicken entrées were cooked to a microbiologically safe end-point temperature. The observation of participants leaving the plastic sheath in place while attempting to measure product temperature highlights consumers' confusion on to properly use standard kitchen food thermometers. However, study participants reported confidence in their food handling practices and did not believe their behaviors put them at risk for contracting a foodborne illness. Consistent with the present study, McCurdy et al. (2005) found that individuals were unconvinced of a need to replace their visual and texture-based methods of determining product doneness. Similarly, Anderson et al. (2004) reported only 5 out of 94 total participants used a thermometer to check doneness of the entrée prepared, while the majority of participants either cut into the meat product or used visual cues to determine doneness (Anderson et al. 2004). Data collected in the present study and others show that most consumers do not use thermometers to determine the doneness of food.

Only a small number (7 percent) of participants were observed adhering to the processors' product label instructions. This finding presents two possibilities: the instructions provided on raw, breaded chicken products are unclear and confusing, or these instructions do not influence the way consumers prepare these products.

This study was limited in several ways. The stores were only visited once during the survey of retail study; therefore, the researcher was only acquiring a snap-shot image of products in the store which may or may not be accurate. The small sample size does not allow for the results to be generalized to the entire population. Participants in any observational study utilizing direct observation may alter their behavior due to their awareness of being watched. Participants were told the goal of the study was generally to evaluate product quality, and product safety was not specifically mentioned by the researchers. The intent of this was to not key the participants' awareness that they would be evaluated on their food safety behaviors, thus, causing them to take precautionary behaviors that they would not normally demonstrate. A limitation associated with using self-reported surveys is the well-documented (Redmond and Griffith 2003b; Berg 2007) tendency toward providing socially desirable responses: participants over-report what they deem as "good behaviors" thereby skewing the results in a positive direction. Adolescents and primary meal preparers were related and the majority of participants knew one another. This presents the possibility of the participants speaking among themselves about the study prior to participating. Finally, the small sample size does not allow the results of the study to be generalized to the entire population.

Despite changes to product labels to improve safe handling practices as advised by USDA-FSIS (Food Safety and Inspection Service 2006b), four cases of salmonellosis were linked to eating undercooked breaded poultry products in March 2008 (United States Department of Agriculture-Food Safety and Inspection Service 2008), indicating the need for continued research in this area. Future studies should use and measure the effect of interventions to modify consumers' perception of individual risk during product preparation and to encourage safe food handling. Such interventions may include studying modified labels to determine how and whether clearer label instructions can generate a stronger adherence by consumers to provided instructions. Additional informational materials apart from the label should also be considered in future research.

Chapter 3: Validation of Provided Cooking Instructions on Raw, Frozen, Pre-Browned Chicken Entrées

Introduction

Frozen, breaded, pre-browned entrées that contain raw poultry have been recognized as a vehicle for *Salmonella*. In the last 15 years, outbreaks of salmonellosis linked to prepared, but not-ready-to-eat (NRTE) poultry products have been identified in Australia, Canada, and the U.S. During outbreak investigations, affected individuals indicated that the pre-browned appearance of the exterior of these products suggested the entrées were fully cooked and only needed to be reheated (Kenny et al. 1999; Smith et al. 1999; MacDougall et al. 2004; Medus 2006a; Medus 2006b; Smith et al. 2008). Therefore, most chose the microwave as an appropriate means of preparation. As a result, the entrée was undercooked and those who consumed the entrée suffered from salmonellosis. Consumers also revealed they do not take the same precautions as they would when handling a visibly raw poultry product (MacDougall et al. 2004).

In response to the 2005–2006 outbreak of salmonellosis associated with the improper cooking of prepared, but NRTE frozen, breaded poultry entrées (Medus 2006a; Medus 2006b), the National Advisory Committee on the Microbiological Criteria for Foods (NACMCF) released a document providing safe cooking guidelines for such products (National Advisory Committee on the Microbiological Criteria for Foods 2006). A minimum internal end-point temperature of 165°F without a hold time was recommended to ensure the microbiological safety of the entrée. Furthermore, NACMCF advised manufacturers to remove the microwave oven as a recommended method for preparing NRTE entrées. Variations in product characteristics in combination with the variability among microwaves ovens make it challenging for manufacturers to develop and validate effective cooking instructions. A limited number of manufacturers have continued to market NRTE entrées as microwavable. If microwaving is listed as a recommended method of preparation, the United States Department of Agriculture-Food Safety Inspection Service (FSIS) has mandated that all instructions be validated to ensure the lethality of any pathogens potentially present in an entrée. While some manufacturers are taking a conservative approach by removing microwave oven cooking instructions, the risk of contracting salmonellosis from NRTE products remains until additional measures are taken (i.e., irradiation or fully cooking all entrées prior to packaging). Furthermore, the removal of microwave preparation instructions from packages does not prevent consumers from preparing such products in the microwave, as evidenced by the identified outbreaks being linked to NRTE products that no longer carried microwave instructions (Smith et al. 2008).

The variation in internal temperature within multi-component foods cooked using a microwave oven has been previously demonstrated (Lindsay et al. 1986; Schnepf and Barbeau 1989; Pucciarelli and Benassi 2005; Dominguez and Schaffner 2009). There are several factors related to both an entrée and an appliance that should be considered when validating cooking instructions. These include: specific heat values of diverse food components, geometry of the entrée, ionic properties, placement within the microwave cavity, and wattage of the microwave oven. Microwave cooking results in thermal destruction of microorganisms (Heddleson and Doores 1994). However, the uneven distribution of heat within an entrée prepared in a microwave oven can lead to the development of cold spots. As a result, pathogens may remain viable in the entrée and be consumed. Multiple studies have reported incomplete inactivation of microorganisms in inoculated food cooked in a microwave oven (Lindsay et al. 1986; Doyle and Mazzotta 2000; Heddleson and Doores 1994; Pucciarelli and Benassi 2005).

The power of a microwave oven has been identified as a variable in evaluating the thermal profiles in an entrée. Furthermore, the wattage of the microwave also plays a role in how quickly and uniformly an entrée will reach a safe internal temperature (United States Department of Agriculture-Food Safety and Inspection Service 2006b). A wide range of microwave ovens can be found throughout consumer kitchens. Bob Schiffman (2010) estimated that there are approximately 150 million microwave ovens in consumers' kitchens today with an annual sales rate of 10 million. Based on the 2008 Year-End Trade Report for Imports, an increase of 7.19 percent was observed for shipments of microwave ovens with wattage of 1000W to 1200W. In contrast, a 39.79 percent decrease was observed for microwave ovens less than 1000W. Despite the decreasing prevalence of low wattage microwave ovens, Mr. Schiffman stated that many consumers still purchase microwaves based on price which favors the lower wattage microwave ovens (Schiffman 2010). Therefore, if microwave cooking is listed as an acceptable preparation method it is important for manufacturers to validate the microwave cooking instructions for each of their products based on multiple wattages rather than focusing on a single wattage. When validating instructions using a single wattage, manufacturers are placing the responsibility of final product safety on the consumer, as consumers would likely need to (or choose to) make cooking time or power level adjustments to account for the variability among microwave ovens when preparing a frozen NRTE entrée.

During the observational study, participants were asked to prepare a breaded chicken entrée and a side salad. As each participant prepared the assigned entrée, their preparation practices were documented using a video-capture system. The resulting video coverage allowed for researchers to evaluate a participant's ability to correctly execute the manufacturer's intended cooking instructions. Common mistakes identified by participants were discussed in Chapter 2 (i.e., failure to flip entrée halfway through cooking or failure to use a microwave safe covering); however, the impact these deviations had on average end-point temperature is unknown. Therefore, using a controlled laboratory setting the current study aimed to validate microwave instructions for each entrée of interest as well as mimic participants' deviations to determine the impact, if any, they had on end-point temperature.

Methodology

Products

Three NRTE products—chicken cordon bleu (CCB), chicken kiev (CK), and breaded chicken strips (CS)—were purchased from a local grocery chain and manufactured at the same processing facility. The stuffed entrées (CCB and CK) were both breaded, boneless breast of chicken with rib meat. The center filling for CCB and CK consisted of pasteurized Swiss cheese/Canadian Brand Ham and butter, spices, and chives, respectively. The net weight for the stuffed entrées was 12 oz (2 six ounce servings) and for the chicken strips was 28 oz (approximately 12 strips). The nutritional information for the specified products can be found in Table 3.1 All products were stored at 0°F until the time of the study.

Table 3.1: Nutrition Facts for Chicken Cordon Bleu, Chicken Kiev, and Chicken Strips

	Chicken Cordon Bleu	Chicken Kiev	Chicken Strips
Fat	15g	26g	9g
Carbohydrate	25g	27g	14g
Protein	29g	23g	19g
Sodium	880mg	760mg	670mg

Cooking Instructions

At the time of the project design (2007), microwave oven cooking instructions were listed as a recommended method for preparation for all three entrées. However, in response to multiple outbreaks of salmonellosis associated with such entrées and published guidance from USDA-FSIS (Food Safety and Inspection Service 2006b), most processors voluntarily chose to remove microwaving instructions from recommended cooking methods during the course of our study. Therefore, this study utilized product labels and recommended cooking instructions (Table 3.2) present on packages prior to the removal of established microwave oven cooking protocols.

Table 3.2: Product label instructions found on each of the NRTE entrées evaluated

Chicken Kiev/Chicken Cordon Bleu
MICROWAVE OVENS – COOK FROM FROZEN (based on 1000 watts of power): Cook on a microwave-safe plate with microwave-safe covering. Cook 1 unwrapped portion for 2 minutes. Turn the piece over and cook for 2 minutes more. For 2 pieces, increase each step by 1 1/2 minutes with spacing between pieces. Do not microwave cook more than 2 pieces at once.
Chicken Strips
MICROWAVE INSTRUCTIONS: The following instructions were from a 600 Watt oven with the power setting on HIGH. Cooking times will vary with oven wattage and power levels. Place a single layer of frozen filets on a dish and heat uncovered on HIGH. 1 filet – 5 minutes 2 filets – 6 minutes 3 filets – 7 minutes Turn filets over and rotate dish halfway through cooking. Let stand 2-3 minutes before serving. If more than 3 filets are desired, divide into two separate heatings for best results. Note: To ensure fully cooked product, make sure the thickest part of the filet is white in color and is at an internal temperature of 165 F when using a food thermometer.

Microwave Oven Experiment

All products were prepared in a 600W microwave oven (Daewoo, Model No. KOR-6LOB) and a 1000W microwave oven (Kenmore, Model No. 721.66029500). Both microwave ovens were purchased new for the study. Treatment parameters were repeated for each product type using these specific appliances.

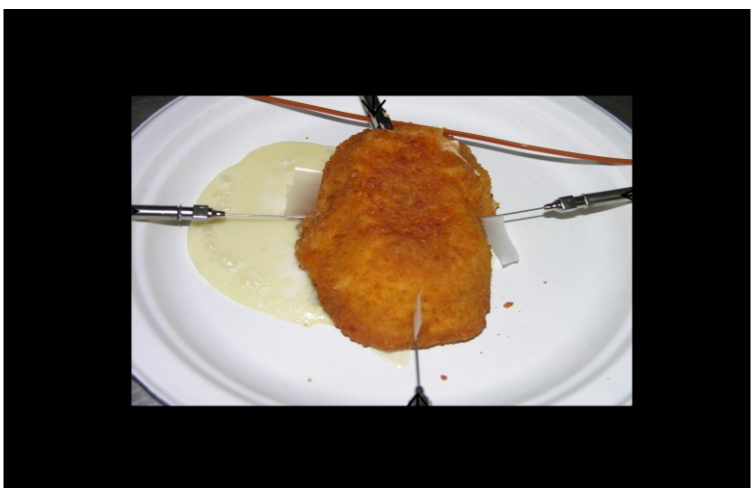
Table 3.3 Brand and dimensions of microwave ovens used in the study

Unit	Manufacturer	Stated Wattage	Height (inches)	Width (inches)	Depth (inches)	Volume (Cubic Feet)
1	Daewoo	600	14.9	20.4	12	0.7
2	Kenmore	1000	11.3	19.8	16.8	1.0

Cooking Treatments

Five repetitions were completed for all treatments for each of the three frozen products in both the 600W and 1000W microwave ovens. A total of four cooking treatments were used. Treatments were determined based on recommendations provided on the product's cooking instructions (Table 3.2). The treatment combinations included: flip/no cover, no flip/no cover, flip/cover, and no flip/cover. Frozen stuffed chicken entrées, when prepared individually, were cooked for a total of four minutes. An additional three minutes of cooking time was added when multiple (2) product units were cooked at the same time. The chicken strips were cooked only as multiple units of strips for a total time of seven minutes. A consumer is instructed to flip an entrée over after 2 minutes of cooking for individual stuffed entrées and 3.5 minutes for both the chicken strips and multiple stuffed entrées. To achieve flipping, the microwave door was opened, the product was flipped, and the door shut and the product was further heated for the remainder of the recommended time. The product when not flipped was left untouched for the recommended cooking time. For treatments that included a cover, entrées were covered during cooking with a plastic microwave-safe covering commonly found in local discount retailers. Immediately following the completion of the cooking period, the products were promptly removed from the microwave oven and four hypodermic probes (HYP-2, Omega Engineering, inc. Stamford, CT) were inserted at specified depths and locations (Figure 3.1). Channel 0 monitored the temperature within the geometric center of the product. Channel 1 and Channel 3 were inserted ¼ inch into the chicken and Channel 2 was inserted ½ inch into the chicken. Temperatures were recorded using a USB-TC data-logging system (Measurement Computing Corporation, Norton, MA) for two minutes.

Figure 3.1: **Thermocouple placement into products during the two minute standing time post-cooking in a microwave oven**



Channel 0 - monitored the temperature of the center filling of the entrée **(A)**

Channel 1 and 3 - inserted ¼ inch into the chicken **(B and D)**

Channel 2 - inserted ½ inch into the chicken **(C)**

Statistical Analysis

The overall experiment was a completely randomized design with the following six factors of interest: product (CK, CCB, CS), microwave wattage (600W, 1000W), flip during cooking (yes, no), cover during cooking (yes, no), number of product units [single (one), multiple (two-stuffed entrées and three-chicken strips)], and location of probe (ch0, ch1, ch2, ch3). The responses measured were maximum and minimum temperature attained by each of the four temperature channels, which were located in various depths within the chicken product. The experimental unit was the chicken product in each cooking session that was outfitted with temperature probes. Five replications of each product treatment combination were conducted.

The initial two analyses were conducted to evaluate the chicken products (CK, CCB, CS) cooked as multiple units simultaneously and as single units for CK and CCB. Chicken strips were only evaluated as multiple units because it is not customary for consumers to prepare only one strip at a time as an entrée. An initial analysis using the General Linear Model (GLM) procedure in Statistical Analysis System (SAS) (SAS Institute 2008, version 9.2) analyzed temperature recording channels separately and also analyzed channel as a repeated measure. The repeat-measures analysis determined that equal correlation between channels was a valid assumption for both a single product unit and multiple product units. Data were then analyzed using the MIXED procedure in SAS as a completely randomized design with a split plot on channel. F-tests (using a significance level of 0.05), means and standard errors for all main effects and interactions were calculated. A Scheffe adjustment was utilized to control inflation of Type I error for pairwise comparison of main effect means for product and channels.

Graphs were created for minimum and maximum temperatures for channel, wattage and product interactions.

A third analysis was conducted where data for products cooked as singles and cooked as multiples were considered together, with number of products being an additional factor in the completely randomized design. This analysis was completed to determine if a difference in average end-point temperature was observed when preparing a single product unit versus multiple product units. In this analysis all data for CS was excluded since this product was only cooked as multiples. Again, an initial analysis using the GLM procedure in SAS was conducted and correlation among channels was determined to be equal. This set of data was then analyzed using the MIXED procedure in SAS. F-tests, means and standard errors for all main effects and interactions were calculated. As in the first analysis, a Scheffe adjustment was used to control inflation of Type I error.

Results

Overview of Results

For each analysis, interactions significantly impacting the overall safety of the product were addressed. Each entrée was examined as a whole in which end-point temperature after 2 minutes of cooking was averaged across all four channels. Secondly, the interaction each channel had with the remaining factors was evaluated. Finally, the effect each factor, individually or in combination, had on each channel separately was evaluated. Only minimum temperature recorded by each channel was addressed as it establishes the greatest risk indicator related to the safety of these prepared chicken entrées.

Results reported here for each of the three analyses (single product unit, multiple product units, and a single product unit compared with multiple product units) include F-test p-values (Table 3.4, 3.6, and 3.8, respectively) and main effect means and standard errors (SE) from both the MIXED analysis with channel as the split-plot factor and the GLM analysis which examined channel separately (Tables 3.3, 3.5, and 3.7, respectively). Interaction plots have been included for significant interactions ($p \leq 0.05$). Plot of means for all significant treatment factor main effects can be found in Appendix F. All interaction plots contain a single black line at 165°F referencing the USDA's recommended safe minimum end-point temperature for poultry. Data points below the reference line represent a probable food safety risk, as a safe end temperature was not achieved across the final cooked product. Additionally, an approximate 95% confidence interval (mean ± 2 SEs) was calculated for treatment combinations in which the average end-point temperature was within 3°F of 165°F. In such circumstances, the lower limit of the confidence interval contained temperatures below 165°F. Therefore, these combinations were considered ineffective because a safe end-point temperature would not always be achieved in subsequent preparations of like entrées under the same conditions. Moreover, an estimate of statistical significance between two average end-point temperatures can be established if a difference of at least 2 SEs is observed (i.e., if an interaction has a SE of 2.31, there must be a difference of at least 4.6°F between two end-point temperatures to be statistically different). Maximum temperatures attained will not be discussed as end-point temperatures exceeded 165°F; therefore, no food safety risk would be expected.

Analysis of minimum temperatures when cooked as a single product unit

Evaluation of the entrée as a whole: Averaging temperature over all channels

Table 3.4 contains the F-test p-values and Table 3.5 contains the main effect means plus SEs for the analysis of a single product unit. The whole plot analysis averaged temperature over all channels and allowed for the determination of impact that each treatment factor, separately or collectively, had on the entrée as a whole.

Table 3.4: F-test p-values with minimum temperatures for the analysis of frozen breaded chicken entrées cooked as single units in a microwave oven

	F Test p-values1				Single Product Unit
	Channels Analyzed Separately; Single Product Unit				Channels as a Factor
	Min0	Min1	Min2	Min3	Min[7]
Product[2]	0.0002	0.5051	0.0291	0.0036	0.0008
Flip[3]	0.3904	0.2496	0.0106	0.4947	0.0243
Cover[4]	0.0571	0.9055	0.1510	0.5155	0.2578
Wattage[5]	0.0036	<.0001	<.0001	<.0001	<.0001
product*flip	0.6487	0.5374	0.0618	0.2464	0.8904
flip*cover	0.0228	0.6314	0.2320	0.2621	0.7274
product*cover	0.6333	0.0870	0.4333	0.2674	0.0762
product*wattage	0.1852	0.7340	0.9310	0.0264	0.7100
flip*wattage	0.2819	0.1003	0.0008	0.9543	0.0094
cover*wattage	0.8905	0.3907	0.0871	0.4817	0.1354
product*flip*cover	0.3559	0.2329	0.2581	0.3102	0.3482
product*flip*wattage	0.0822	0.4503	0.3528	0.0934	0.1793
flip*cover*wattage	0.5545	0.7422	0.3393	0.4984	0.4271
product*cover*wattage	0.1125	0.7428	0.9089	0.9156	0.6444
Ch[6]					0.0001
Product*Ch					0.0074
flip*ch					0.4085
Product*flip*ch					0.0904
cover*ch					0.2229
product*cover*ch					0.7522
flip*cover*ch					0.0429
product*flip*cover*ch					0.2625
wattage*ch					<.0001
product*wattage*ch					0.0538
flip*wattage*ch					0.0465
cover*wattage*ch					0.6631
flip*cover*wattage*ch					0.7717

[1] p-values highlighted in grey are significant ($p \leq 0.05$).
[2] Only Chicken Cordon Bleu and Chicken Kiev were cooked as a single product unit.
[3] Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time.
[4] Covering was achieved by using a plastic microwave safe covering during the recommended cooking time.
[5] Two wattage of microwave ovens were used – 600W and 1000W
[6] Channel designations: Ch0 inserted into center filling, Ch1 and Ch3 inserted ¼" into chicken, Ch2 inserted ½" into chicken.
[7] Min = minimum end-point temperature observed on each channel.

Table 3.5: Minimum end-point temperature means with standard errors for the analysis of frozen, breaded chicken entrées cooked as single units in a microwave oven.

	Minimum Temperature Means with Standard Error (°F)				Single Units (°F)
	Single Units By Channel[1]				Means Across Ch[2]
FLIP	**0**	**1**	**2**	**3**	**Min**
Flip	182	171	176	166	a[3] 174
No Flip	178	165	161	162	b 166
Standard Error	3.53	4.15	4.03	4.06	2.31
COVER					
Cover	175	168	164	166	168
No Cover	185	168	173	162	172
Standard Error	3.53	4.15	4.03	4.06	2.31
WATTAGE					
W1000	188	185	193	184	a 188
W600	173	151	143	144	b 153
Standard Error	3.53	4.15	4.03	4.06	2.31
PRODUCT					
Bleu	171	170	162	155	a 164
CK	190	166	175	173	b 176
Standard Error	3.53	4.15	4.03	4.06	2.31
CHANNEL					
0					a 180
1					b 168
2					b 168
3					b 164
Standard Error					2.79

[1]Channel designations: Ch0 inserted into center filling, Ch1 and Ch3 inserted ¼" into chicken, Ch2 inserted ½" into chicken.

[2]End-point temperatures for a single unit averaged over all channels.

[3]Different letters (a,b) indicate that mean minimum temperatures recorded across recording channels are different ($p \leq 0.05$).

Figure 3.2 illustrates the impact flipping at the mid-point of the recommended cooking time had on end-point temperature when an entrée was prepared in both low

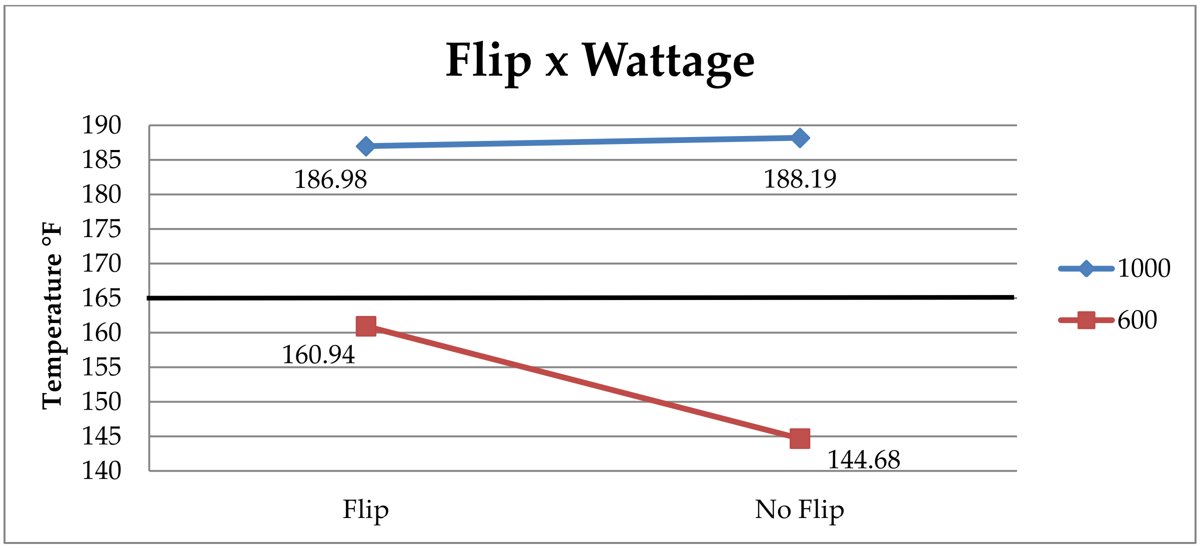


Figure 3.2 Plot of means for the significant Flip x Wattage interaction observed when a single product unit was prepared in a microwave oven.

Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time; Wattage = 600W, 1000W; Single product unit = chicken cordon bleu and chicken kiev cooked one at a time; n=5; p-value 0.0094.

and high wattage microwave ovens. All entrées prepared in the 1000W microwave oven could be considered overcooked with an average end-point temperature that exceeded 165°F by approximately 22°F. In contrast, when prepared in a 600W microwave oven average end-point temperatures failed to reach the recommended safe internal temperature of 165°F. When prepared in a 600W microwave oven and flipped, the average end-point temperature was approximately 16°F greater than the observed temperature achieved when the entrée was not flipped (160.94°F versus 144.68°F). Overall, flipping had little to no effect on end-point temperature when an entrée was prepared in a high wattage microwave oven, but when prepared in a low wattage microwave oven flipping led to a higher end-point temperature. Despite a higher end-point temperature, the cooked product still did not reach the recommended 165°F standard by the USDA.

Evaluation of channels: The effect of channel and its interaction with other factors

Split-plot analysis helped to determine if the conditions applied during cooking result in an even distribution of heat throughout an entrée. Examining each temperature recording location individually (channel) revealed whether certain product areas were consistently undercooked. Of the 16 interactions analyzed only six were significant ($p\text{-value} \leq 0.05$). The discussion will begin with one of two three-way interactions, specifically, Flip x Wattage x Channel (Figure 3.3). From the three-way

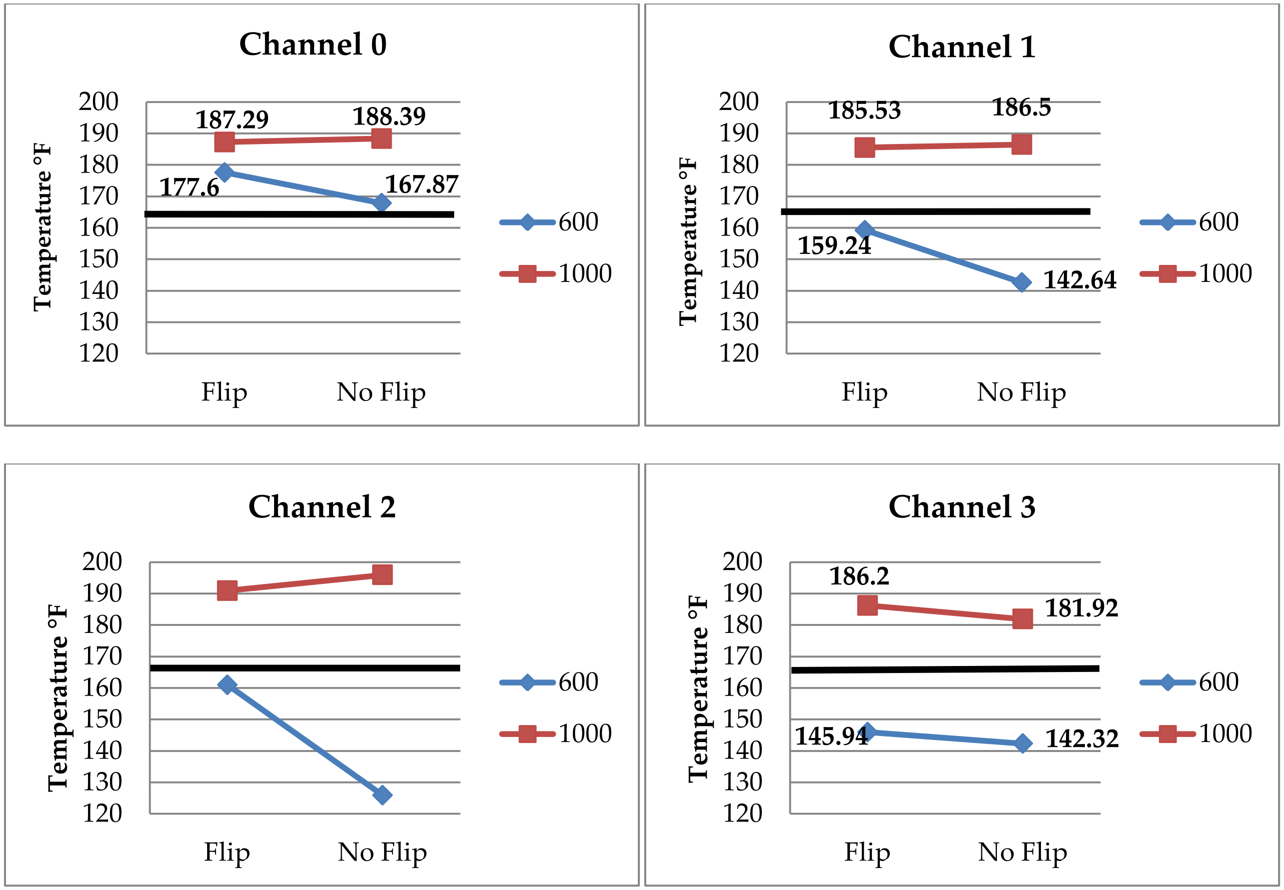


Figure 3.3: Plot of means for the significant Flip x Wattage x Channel interaction observed when a single product unit was prepared in a microwave oven.

Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time; Wattage = 600W, 1000W; Channel designations: Ch0 = inserted into center filling, Ch1 and Ch3 = inserted ¼″ into chicken, Ch2 = inserted ½″ into chicken; single product unit = chicken cordon bleu and chicken kiev cooked one at a time; n=5; p-value 0.0465.

interaction, a significant two-way interaction, Wattage x Channel (Figure 3.4), can be extracted and will also be addressed. Following the discussion of the three-way and two-way interactions, a second three-way interaction, Flip x Cover x Channel (Figure 3.5), will be discussed. The final two-way interaction, Product x Channel (Figure 3.6).

Figure 3.3, broken down by channel, illustrates the effect flip and wattage collectively had on end temperature. Similar to the whole-plot analysis, end temperatures at all measurement locations were greater than the recommended 165°F when the products were prepared in a 1000W microwave oven. However, when an entrée was prepared in a 600W microwave oven, temperatures at three of the four measurement locations were less than 165°F (ranged from 145.94°F to 160.97°F). The center (channel 0) was the only portion of the entrée to exceed 165°F.

When prepared in the 1000W microwave oven regardless of whether flipped or not flipped the resulting entrée is fully cooked (Figure 3.3). Furthermore, the 5°F difference in end-point temperature among all channels suggests a uniform distribution of heat throughout the entrée (185.53°F to 190.91°F). In comparison, higher end-point temperatures were achieved on all channels in the 600W microwave oven when flipped compared to not flipped; however, all prepared entrées failed to reach the recommended 165°F.

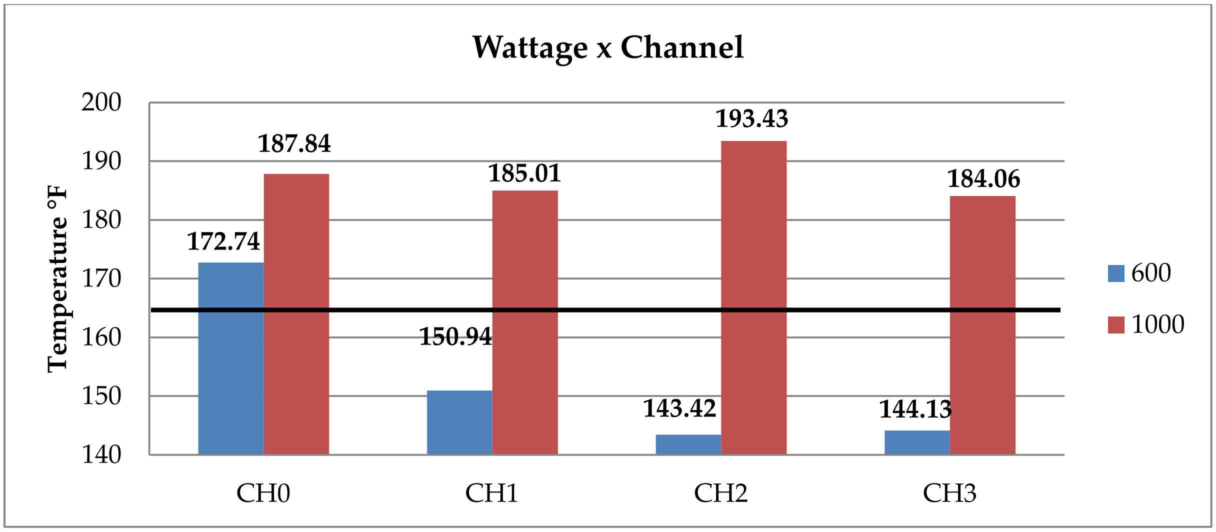


Figure 3.4: Plot of means for the significant Wattage x Channel interaction observed when a single product unit was prepared in a microwave oven.

Wattage = 600W, 1000W; Single product unit = chicken cordon bleu and chicken kiev cooked one at a time; Channel designations: Ch0 = inserted into center filling, Ch1 and Ch3 = inserted ¼″ into chicken, Ch2 = inserted ½″ into chicken, Ch3 = inserted ¼″ into chicken n=5; p-value <.0001.

Channel 0, measuring the temperature at the geometric center of each entrée, was the only channel to reach a safe end temperature. In contrast to the 1000W microwave, a uniform distribution of heat was not achieved in the 600W microwave oven as a 32°F difference in temperature was observed throughout the entrée (145.94°F to 177.6°F).

Figure 3.4 depicts the interaction between wattage and channel. Similar to the three-way interaction (Flip x Wattage x Channel), an entrée prepared in a 1000W microwave oven was fully cooked on all channels with end-point temperatures ranging from 184.06°F to 193.43°F, approximately a 9°F difference between the lowest and highest average end-point temperatures. In comparison, when prepared in the 600W microwave oven, the three channels inserted ¼″ and ½″ into the chicken registered temperatures below 165°F. Furthermore, a uniform distribution in heat was not observed as end temperatures ranged from 143.42°F to 172.74°F (29°F difference). Based on end-point temperature observations, both wattages yielded undesirable results, as entrées prepared in the 600W microwave oven were undercooked (thus possibly unsafe) while entrées prepared in the 1000W microwave oven were overcooked (as indicated by temperature; no sensory analysis was conducted).

Figure 3.5 details the effect flip and cover had on end-point temperature on a by-channel basis. Cooking instructions provided by the manufacturer instruct consumers to flip the entrée halfway through cooking and cover the entrée with a microwave-safe covering. When prepared per the manufacturer's recommendations, no difference in end temperature was observed when comparing flip/cover versus flip/no cover on channel 1 (inserted 1/4" into the chicken) and channel 2 (inserted ½" into the chicken). The difference between end-point temperatures did not exceed 2 SEs and therefore was not significant. In contrast, a significant difference (greater than 2 SEs apart) was observed on channel 0 (inserted into geometric center of product) and channel 3 (inserted ¼" into the chicken). However, when prepared per the manufacturer's recommended conditions (flipped and covered) all channels exceeded 165°F with end-point temperatures ranging from 171.20°F to 175.24°F. Furthermore, the combination of flip and cover increased the uniformity of heat throughout the entrée, as there was only a 4°F difference in end temperature across the four channels. However, the SE for this

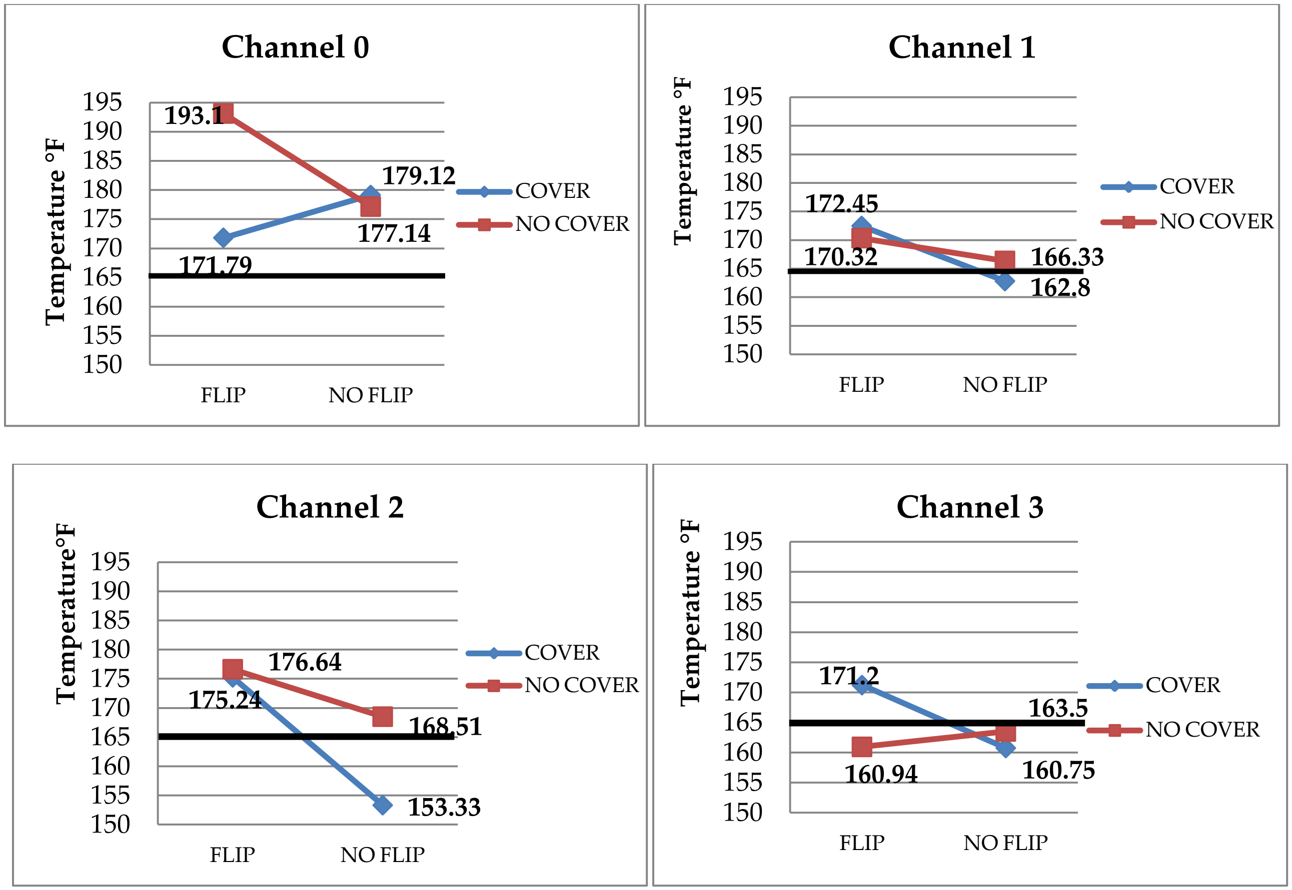


Figure 3.5: Plot of means for the significant Flip x Cover x Channel interaction observed when a single product unit was cooked in a microwave oven.

Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time; Covering was achieved by using a plastic microwave safe covering during the recommended cooking time; Channel designations: Ch0 = inserted into center filling, Ch1 and Ch3 = inserted ¼" into chicken, Ch2 = inserted ½" into chicken; Single product unit = chicken cordon bleu and chicken kiev cooked one at a time; n=5; p-value 0.0429.

three-way interaction was 5.59. Therefore, despite registering fully cooked end-point temperatures, when prepared again under the same conditions the potential exists for internal temperatures to fall below the recommended 165°F. Nevertheless, other combinations of the two treatment factors (i.e., no flip/cover and no flip/no cover) failed to result in a safe end product as one or more of the channels did not exceed 165°F.

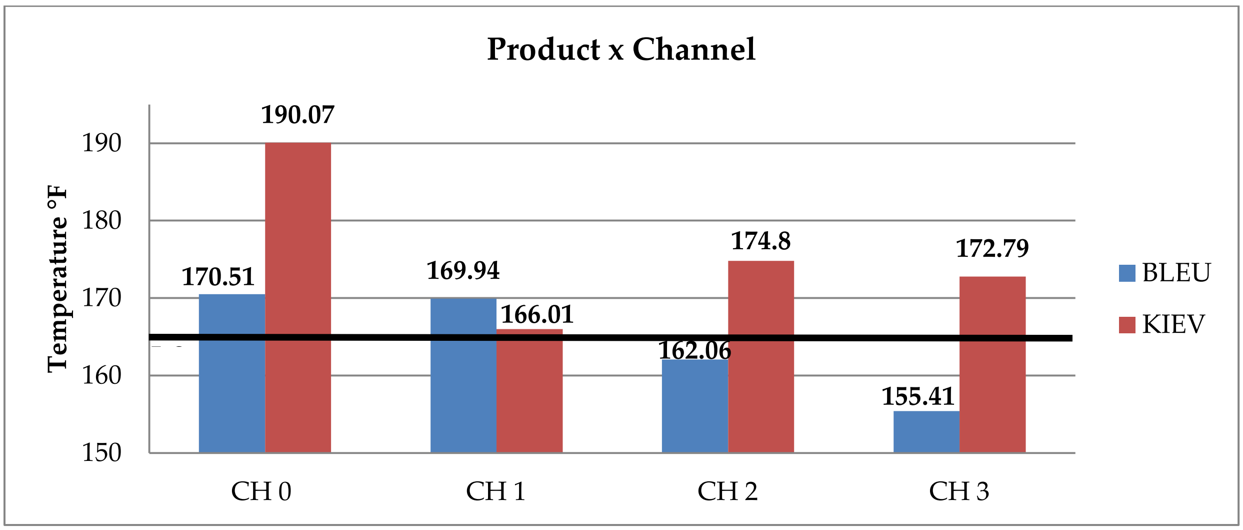


Figure 3.6: Plot of means for the significant Product x Channel interaction when a single product unit was cooked in a microwave oven.

Single product unit = chicken cordon bleu and chicken kiev cooked one at a time; Channel designations: Ch0 = inserted into center filling, Ch1 and Ch3 = inserted ¼" into chicken, Ch2 = inserted ½" into chicken; n=5; p-value 0.0074.

The USDA-FSIS requires all cooking methods on the product label be validated. In doing so, manufacturers confirm that a safe end product can result when prepared per their provided recommendations. Manufacturers often market a variety of stuffed entrées. As a result, the same cooking protocol is validated for a group of like entrées (all stuffed products) rather than individual entrées (chicken cordon bleu versus chicken kiev) (Grocery Manufacturer's Association 2008). Figure 3.6 directly compares the end-point temperatures of the CCB and CK products when prepared under the same conditions. Of the two, CK was the only entrée to reach a safe end-point temperature on all channels. The center filling for both entrées reached the highest end-point temperature. However, the end-point temperature at the center of the product for CK was approximately 20°F greater than the end-point temperature for CCB. The observed difference can possibly be attributed to the make-up of the center filling. Chicken Kiev contains a seasoned butter filling which has a lower specific heat than the center filling for CCB (fully cooked ham and cheese) and therefore will heat at a quicker rate than the CCB.

Manufacturers instruct consumers to check the internal temperature of the entrée in the thickest part with a meat thermometer. The thickest portion (i.e., the center) for each of the stuffed entrées evaluated in the study contained fully cooked components. Therefore, when prepared in a 600W microwave oven and per the manufacturer's directions, CCB reached a safe end-point temperature on only two of the four channels—channel 0 (170.51°F) and channel 1 (169.94°F). Therefore, when following manufacturer's recommendations and checking the internal temperature at the thickest section (center; channel 0), a consumer would be led to believe the entrée was fully cooked when in reality half of the entrée did not reach the recommended 165°F. Channels 2 and 3 were undercooked reaching only 162.06°F and 155.41°F, respectively.

Analysis of minimum temperatures when multiple product units were cooked simultaneously

Evaluation of the entrée as a whole: Averaging temperature over all channels

Table 3.6 contains the F-test p-values and Table 3.7 contains the main effect means plus standard errors for the analysis of data resulting from cooking multiple product units simultaneously in a microwave oven. Whole plot analysis averages temperature over all channels. This analysis allows the determination of impact each treatment factor, separately or collectively, had on an entrée. Of the 14 interactions evaluated, only six were significant ($p \leq 0.05$) and will be discussed below. The discussion will begin with Product x Flip x Wattage (Figure 3.7). From this interaction, three two-way interactions can be extracted; however, only Product x Flip (Figure 3.**8**) was significant and will be the only one addressed. A second three-way interaction, Product x Flip x Cover (Figure 3.9), was also significant. Similar, to the above three-way interaction, only one of the two-way interactions, Product x Cover (Figure 3.10) was significant.

Figure 3.7 illustrates the impact flip and wattage had on each entrées (CCB, CK, and CS) end-point temperature. When prepared in a 1000W microwave oven, a significant difference in end temperature was not observed between entrées when flipped versus not flipped. Furthermore, average end-point temperatures exceeded 165°F by nearly 30°F. In contrast, entrées prepared in a 600W microwave oven failed to

Table 3.6: F-test p-values with minimum temperatures for the analysis of frozen breaded chicken entrées cooked as multiple product units in a microwave oven.

	F Test p-values[1]				Multiples
	Channels Analyzed Separately; Multiples				Channels as a Factor
	Min0	Min1	Min2	Min3	Min[7]
Product[2]	0.0020	0.2856	<.0001	0.0010	0.0415
Flip[3]	0.1665	0.1674	0.5467	<.0001	0.5171
Cover[4]	0.6975	0.6730	0.3591	0.4729	0.3662
Wattage[5]	<.0001	<.0001	<.0001	<.0001	<.0001
product*flip	0.0190	0.1551	0.0116	0.8090	0.0256
flip*cover	0.2398	0.9984	0.3656	0.9786	0.7791
product*cover	0.0034	0.7956	0.0709	0.1078	0.0129
product*wattage	0.0002	0.0320	0.0002	0.7665	0.2019
flip*wattage	0.1238	0.1033	0.3112	0.0250	0.7804
cover*wattage	0.8248	0.7815	0.1423	0.1347	0.4378
product*flip*cover	0.3263	0.2666	0.0638	0.0406	0.0253
product*flip*wattage	0.0291	0.0778	0.0150	0.4579	0.0163
flip*cover*wattage	0.3310	0.9322	0.5495	0.2443	0.8937
product*cover*wattage	0.0128	0.7806	0.2452	0.1586	0.0827
Ch[6]					<.0001
Product*Ch					<.0001
flip*ch					<.0001
Product*flip*ch					0.0852
cover*ch					0.9959
product*cover*ch					0.0813
flip*cover*ch					0.442
wattage*ch					<.0001
product*wattage*ch					<.0001
flip*wattage*ch					0.0028
cover*wattage*ch					0.3892

[1] p-values highlighted in grey are significant ($p \leq 0.05$).
[2] Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips).
[3] Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time.
[4] Covering was achieved by using a plastic microwave safe covering during the recommended cooking time.
[5] Two wattage of microwave ovens were used – 600W and 1000W
[6] Channel designations: Ch0 inserted into center filling, Ch1 and Ch3 inserted ¼" into chicken, Ch2 inserted ½" into chicken.
[7] Min = minimum end-point temperature observed on each channel.

Table 3.7: Minimum end-point temperature means with standard errors for the analysis of frozen, breaded chicken entrées cooked as multiple product units in a microwave oven.

	Means with Standard Error (°F)				Multiple Units (°F)
	Multiple Units By Channel[1]				Means Across Ch.[2]
FLIP	**0**	**1**	**2**	**3**	**Min**
Flip	156	169	182	176	171
No Flip	164	175	180	159	170
Standard Error	3.16	3.06	2.04	2.60	1.73
COVER					
Cover	160	171	180	166	169
No Cover	162	173	183	169	172
Standard Error	3.16	3.06	2.04	2.60	1.73
WATTAGE					
W1000	198	194	197	184	a[3] 193
W600	123	151	166	151	b 148
Standard Error	3.16	3.06	2.04	2.60	1.73
PRODUCT					
Bleu	154	170	186	157	a 169
Kiev	156	170	186	167	ba 170
Strips	172	177	171	178	b 175
Standard Error	3.87	3.75	2.50	3.19	2.12
CHANNEL					
0					a 161
1					b 172
2					c 181
3					ba 167
Standard Error					1.95

[1]Channel designations: Ch0 inserted into center filling, Ch1 and Ch3 inserted ¼″ into chicken, Ch2 inserted ½″ into chicken.

[2]End-point temperatures for a single unit averaged over all channels.

[3]Different letters (a,b) indicate that mean minimum temperatures recorded across recording channels are different ($p \leq 0.05$).

reach a safe internal temperature. A significant difference (difference between end-point temperatures did not exceed 2SEs; SE = 4.24) was not observed when comparing the end-point temperatures achieved when CCB was flipped versus not flipped. Moreover, end temperatures were 20°F below the recommended 165°F. In contrast, a higher end-point temperature was achieved when CK was not flipped, but it was still below 165°F.

Finally, when using a 600W microwave oven, the average end-point temperature of CS was just below 165°F (164.64°F) when flipped, but only reached 145°F when not flipped. While temperature for the 600W flipped was slightly below the 165°F target, the SE for this three-way interaction was 4.24 meaning the approximate 95% confidence interval was 156.23°F to 173.05°F. Therefore, when prepared again under the same conditions, a safe end temperature may not be attained as the lower limit of the confidence interval included temperatures 8°F below the necessary 165°F.

The three-way interaction, Product x Flip x Wattage, can be broken out into three two-way interactions. However, only Product x Flip was significant ($p \leq 0.05$). Figure 3.8 compares the impact flip versus no flip had on end-point temperature for each of the prepared entrées. Similar to the three-way interaction, a significant difference in end-point temperature was not observed when CCB was flipped/not flipped halfway through cooking, but was significant for the CS and CK. When flipped, CK achieved a

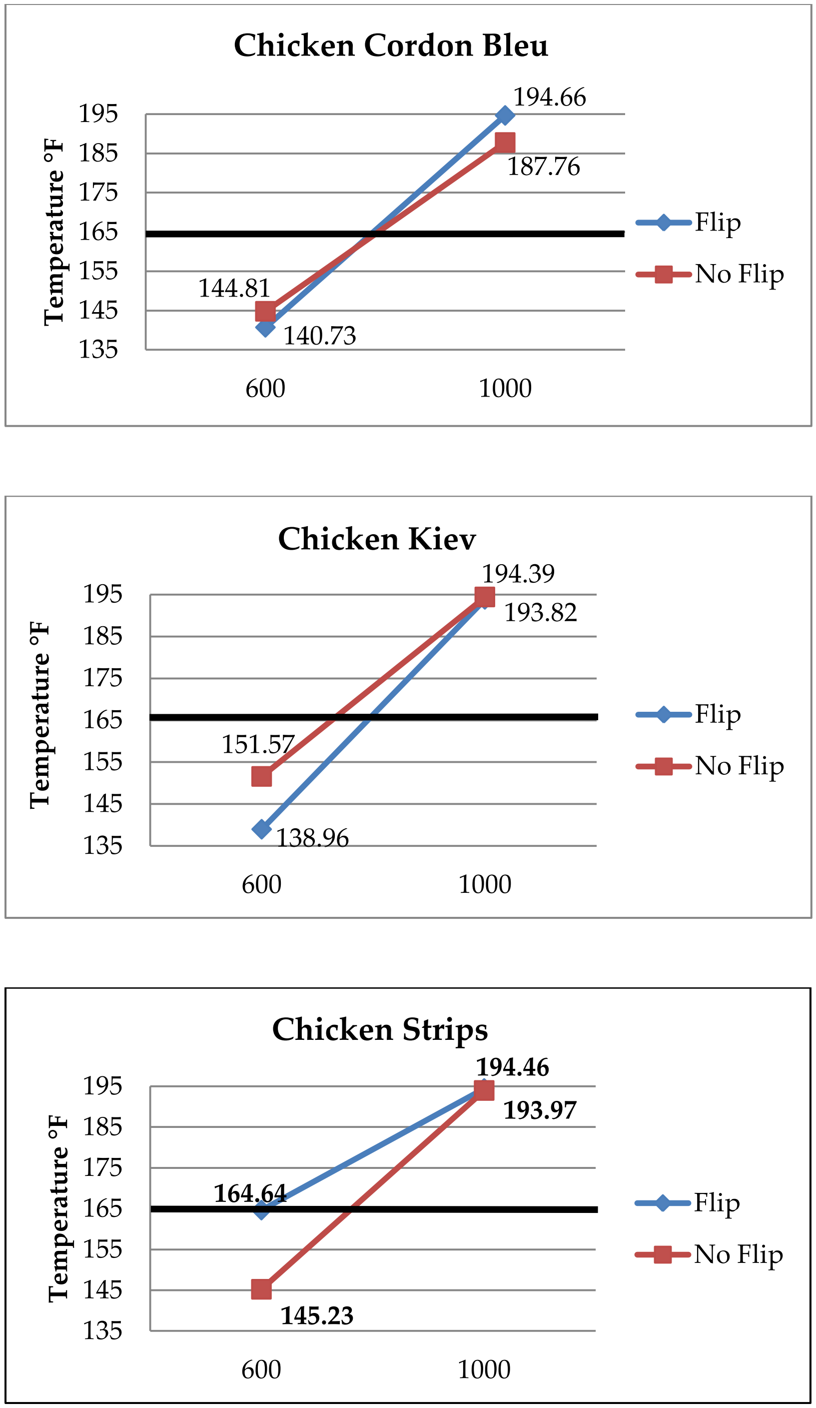


Figure 3.7: Plot of means for the significant Product x Flip x Wattage interaction observed when multiple product units were prepared in a microwave oven.

Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time; Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); Two wattage of microwave ovens were used – 600W and 1000W; n=5; p-value = 0.0163.

lower end temperature (still greater than 165°F) than when not flipped. In contrast, when prepared per the recommendations a final end temperature approximately 15°F above the recommended 165°F was observed. However, for all products, regardless of whether flipped or not flipped, the safe recommended end-point temperature of 165°F was achieved thereby resulting in a safe end product. Similar to the three-way interaction, the approximate 95% confidence interval (SE 2.99) contained temperatures less than 165°F for all three entrées. Therefore, while fully cooked were observed, it is possible that a safe end temperature of 165°F may not be achieved when prepared again under like conditions (i.e., CCB flipped/not flipped, CK flipped, and CS not flipped).

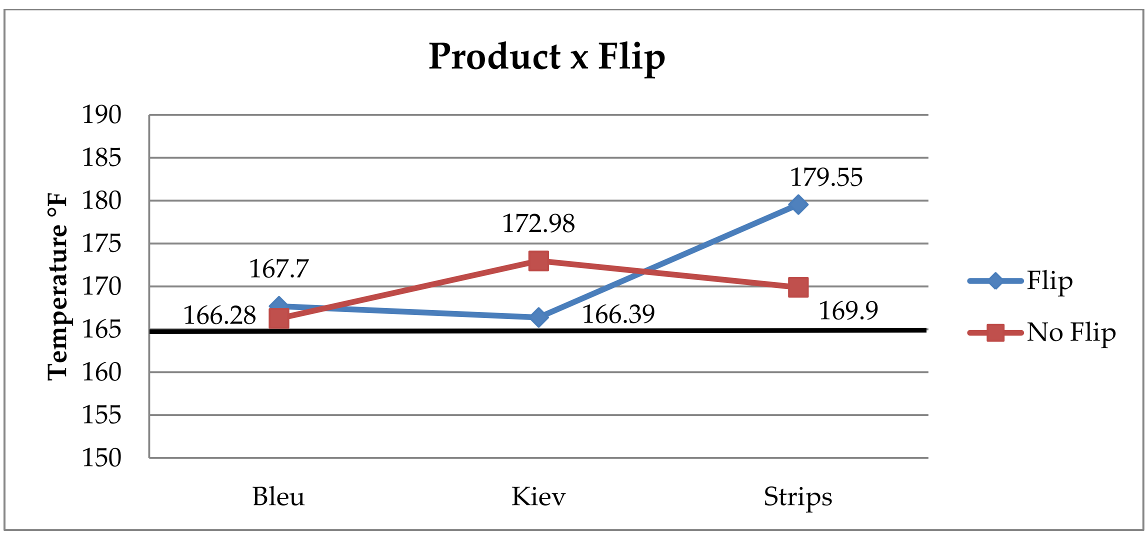


Figure 3.8: Plot of means for the significant Product x Flip interaction observed when multiple product units were cooked in a microwave oven.

Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time; Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); n=5; p-value = 0.0253.

Figure 3.9 illustrates the effect manufacturer's recommendation to flip and cover an entrée during cooking had on end-point temperature for the entrées. Manufacturer's instructions prior to being placed on the label have been validated thereby guaranteeing, if followed correctly, a fully cooked entrée should result. Results suggest that when instructions are followed (flipping the product halfway through cooking AND covering the product with a microwave safe covering), a fully cooked entrée does not always result. Of the three products evaluated, CCB was the only product that was not fully cooked when both covered and flipped as the end-point temperature was only 159.8°F. Based on observed end-point temperature, the most efficient combination for cooking CCB was flip, but not cover as the end-point temperature was 175.59°F. When the manufacturer's recommendations of cover and flip were applied to both CK and CS, the end-point temperatures achieved were 170.47°F (CK) and 178.99°F (CS). Flipping of CK provided an approximate 8°F higher end-point temperature than not flipping; however, when flipping, but not covered a safe internal temperature of 165°F was not achieved. Conversely, when CS was not flipped or covered the resulting product was fully cooked; however, if flipped, but not covered the average end temperature observed was 161.81°F. Therefore, based on observed average end-point temperatures the ideal combination for CCB would be to flip and not cover, but for CK the recommendation should be to cover (regardless of flipping). For CS, the instructions should be to flip the product (regardless of covering). An unsafe end product resulted

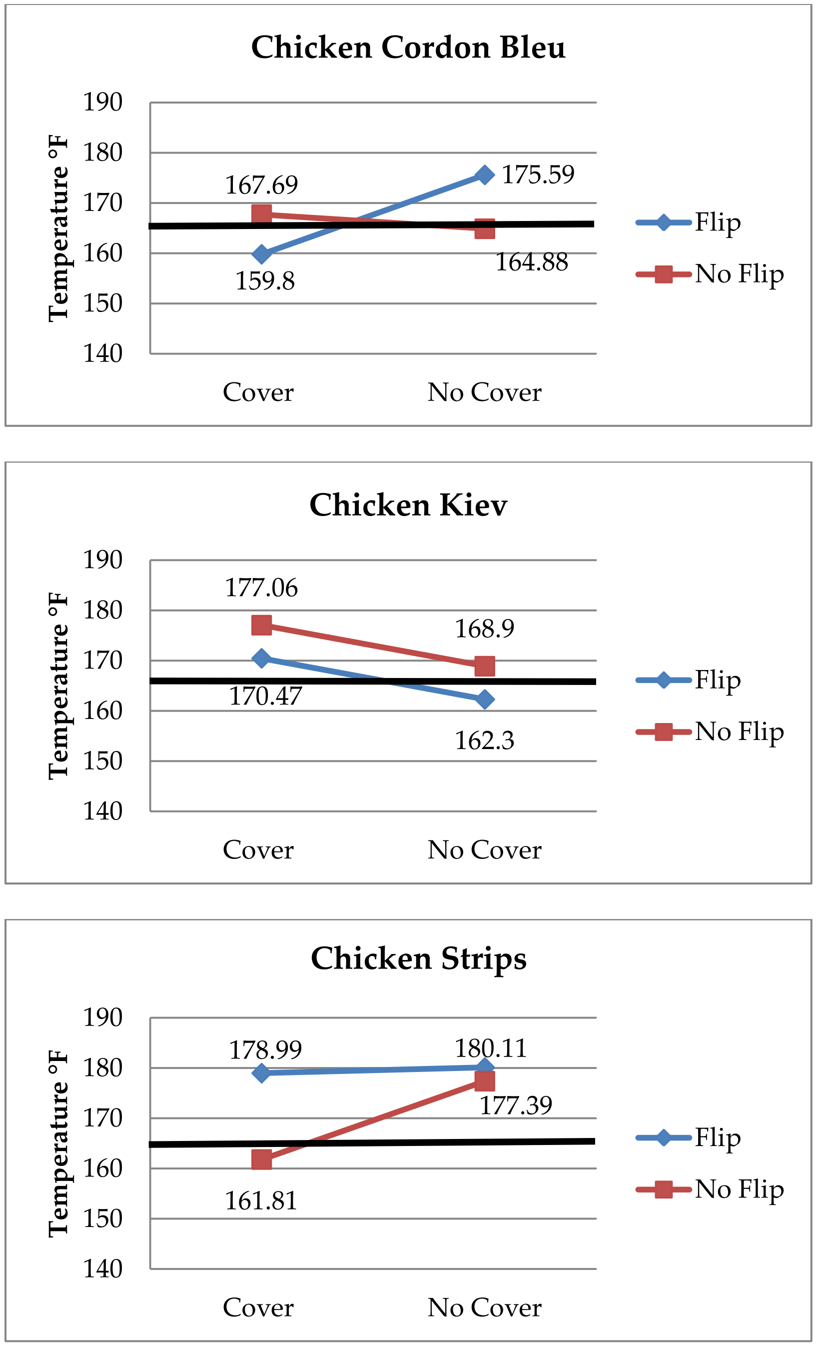


Figure 3.9: Plot of means for the significant Product x Flip x Cover interaction observed when multiple units were prepared in a microwave oven.

Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time; Covering was achieved by using a plastic microwave safe covering during the recommended cooking time; Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); n=5; p-value = 0.0253.

when the provided instructions were not followed correctly. Moreover, CCB remained undercooked when flipped and covered with a microwave safe covering. However, for the remaining entrées, safe end products were achieved when the manufacturer's instructions were applied. A unique set of instructions should be validated for individual entrées.

Manufacturers often instruct consumers to cook an entrée on a microwave safe plate with a microwave safe covering. Figure 3.10 illustrates the impact that covering an entrée during cooking had on end-point temperature. Cordon Bleu was the only entrée when covered not to achieve an internal temperature of 165°F. In contrast, all products when not covered resulted in safe end-point temperatures (>165°F). However, while safe, the end temperature for CK barely exceeded 165°F (165.6°F). Therefore, the approximate 95% confidence interval, 159.61°F to 171.59°F, contained temperatures less than the recommended 165°F. Therefore, the potential exists for an entrée, when not covered, to remain uncooked even after cooking for the recommended time. In contrast to the CK, both the CCB and CS reached a higher end-point temperature when not covered. Manufacturers recommend consumers cover food products during cooking in a microwave oven to maintain moisture which aids in destroying harmful bacteria and increases uniform heating (Heddleson and Doores 1994). However, while covering may help to reduce harmful bacteria should they be present, it does not ensure a safe end temperature will result each time an entrée is prepared. Our data suggests that products respond differently when covered during microwave cooking.

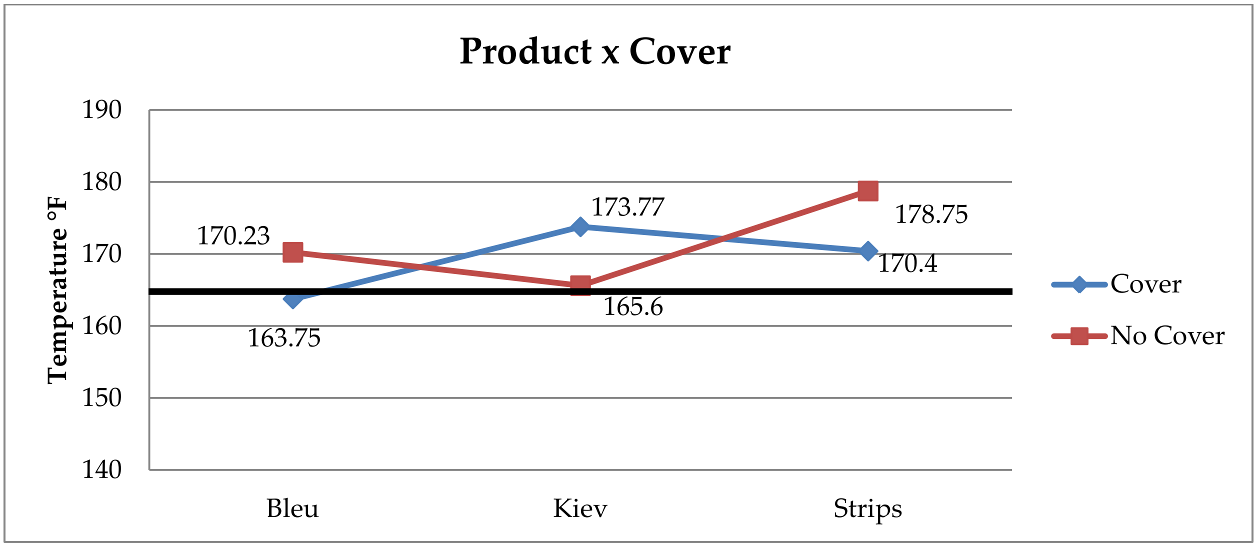


Figure 3.10: Plot of means for the significant Product x Cover interaction observed when multiple product units were cooked in a microwave oven.

Covering was achieved by using a plastic microwave safe covering during the recommended cooking time; Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); n=5; p-value = 0.0153.

Evaluation of channels: The effect of channel and its interaction with other treatment factors

Split-plot analysis helps determine if uniform heating occurred when entrées were prepared as multiple product units. Of the 16 interactions analyzed only six were significant (p-value ≤ 0.05). The discussion will begin with one of two three-way interactions, specifically, Flip x Wattage x Channel (Figure 3.11). From this interaction, two significant two-way interactions, Flip x Channel (Figure 3.12) and Wattage x Channel (Figure 3.13), can be extracted. The second three-way interaction, Product x Wattage x Channel (Figure 3.14), will then be discussed.

Similar to the whole-plot analysis, products prepared in the 1000W microwave oven were not considered a food safety risk, as all entrées reached temperatures greater than 165°F (Figure 3.11). In contrast, breaded chicken entrées prepared in the 600W microwave oven are a food safety risk as almost all channels failed to reach a safe minimum internal temperature of 165°F. As a result, the following discussion will focus only on the 600W microwave oven.

Figure 3.11 illustrates the effect product flipping and wattage had on end-point temperature on a by-channel basis. A higher internal temperature was achieved on channels 0 and 1 when not flipped, but the opposite was observed on channels 2 and 3 in which flipping the entrée led to a higher average end-point temperature. Channel 2 was the only channel to achieve the recommended end-point temperature, and only when flipping was utilized. However, it should be noted that the SE for this interaction was 3.89, meaning that the lower end of the confidence interval (160.92°F – 175.95°F) encompassed temperatures less than 165°F. Therefore, the potential exists for products not to reach a safe internal temperature when prepared again under the same conditions. Overall, when flipped and cooked in a 600W microwave oven, 75 percent of the entrée was undercooked as temperatures recorded on channels 0, 1, and 3 ranged

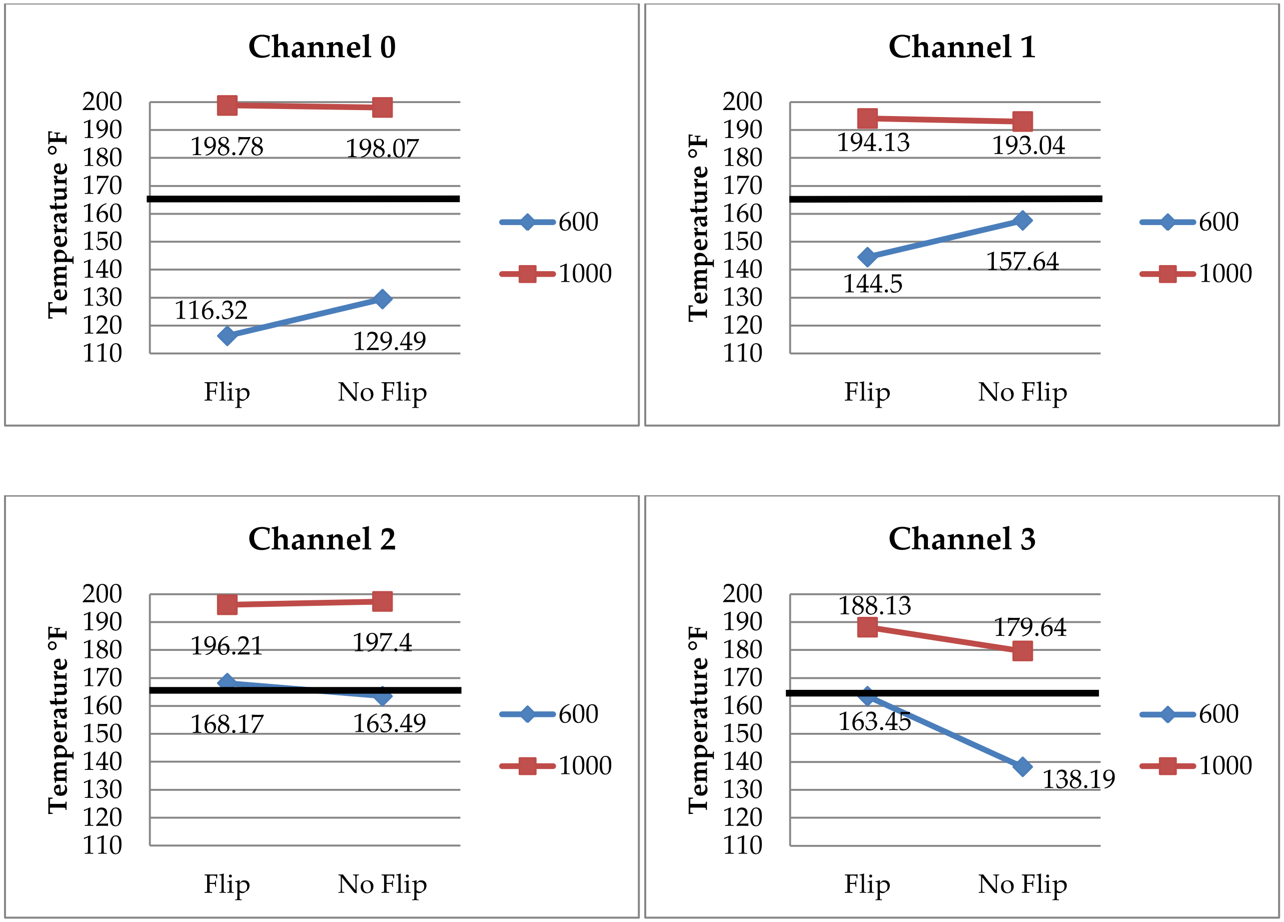


Figure 3.11: Plot of means for the significant Product x Wattage x Channel interaction when multiple product units were cooked in a microwave oven.

Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time; Wattage = 600W, 1000W; Channel designations: Ch0 = inserted into center filling, Ch1 and Ch3 = inserted ¼″ into chicken, Ch2 = inserted ½″ into chicken; Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); n=5; p-value 0.0028.

from 116.32°F to 163.45°F. Furthermore, when the product was not flipped, all channels registered temperatures below the recommended 165°F (129.49°F to 163.49°F).

Cooking directions instruct consumers to flip a product half-way through cooking. Results indicate that flipping an entrée at the halfway point does not guarantee an increased distribution of heat throughout the entrée (Figure 3.11). Two of the four channels (0 and 1), when flipped, recorded lower temperatures than when not flipped. Channel 2 was the only channel to reach a safe end temperature when flipped, and all channels failed to reach a safe end-point temperature when not flipped.

An end-point temperature of 163.45°F was recorded on channel 3 when entrées were flipped; however, when not flipped a 25 degree drop in internal temperature was observed. The drop in temperature illustrates the importance of flipping an entrée during the cooking process to increase the uniformity of heat distribution. When not flipped, the distribution of microwaves between products is uneven resulting in lower end-point temperatures on the inner portions of the entrées (monitored by Ch3).

The following two figures detail two significant two-way interactions that were extracted from the three-way interaction Flip x Wattage x Channel. Figure 3.12 details the significant interaction ($p < .0001$) between product flipping and channel. When the product was flipped half-way through cooking, as instructed on the cooking recommendations, three of the four channels reached a safe end-point temperature.

Similar to the three-way interaction, channel 0 (the thickest portion of the entrée) again failed to achieve a safe internal temperature and was approximately 7°F below the recommended 165°F.

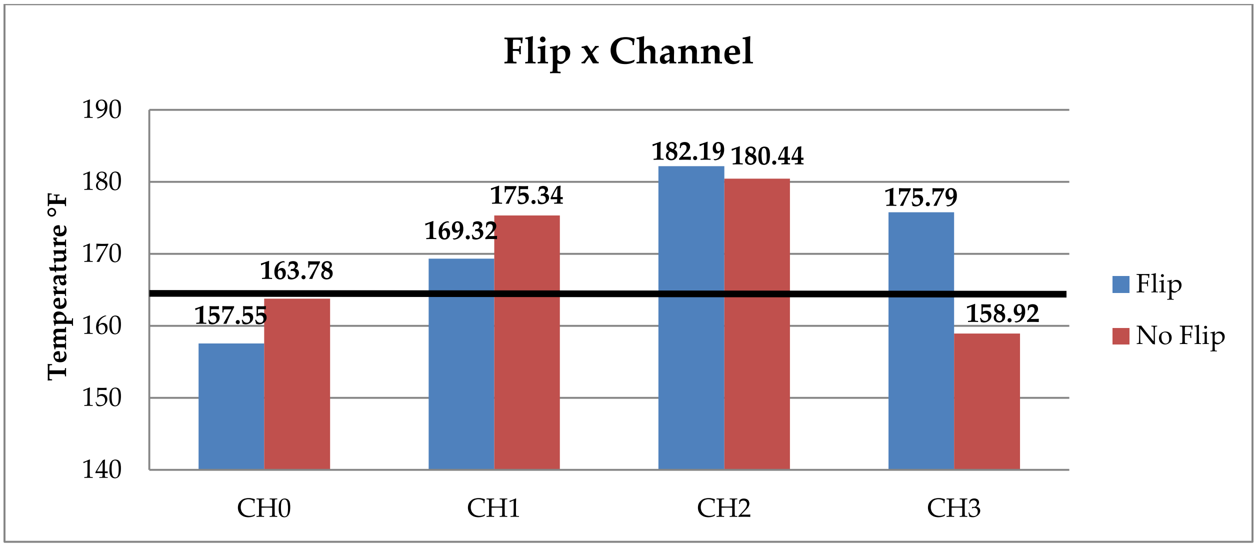


Figure 3.12: Plot of means for significant Flip x Channel interaction when multiple product units were prepared in a microwave oven.

Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time; Channel designations: Ch0 = inserted into center filling, Ch1 and Ch3 = inserted ¼" into chicken, Ch2 = inserted ½" into chicken; Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); n=5; p-value <.0001.

Regardless of whether products were flipped or not flipped, heating was not uniform, thereby resulting in "cold spots" throughout the product. It is likely that a consumer may only check the entrée's temperature in one location, if at all. In checking the entrée temperature in a single location, the consumer has failed to follow label instructions as it clearly states to check the temperature in multiple locations. Figure 3.12 demonstrates that channel 0 failed to reach a safe end temperature when prepared in a low wattage microwave oven. Therefore, if following the recommendations to check the internal temperature in the thickest location (i.e., the center or channel 0) a consumer will be aware the entrée is not fully cooked as an end temperature of 157.55°F. Therefore, a consumer should return the product to the microwave and continue cooking until a safe end temperature has been achieved.

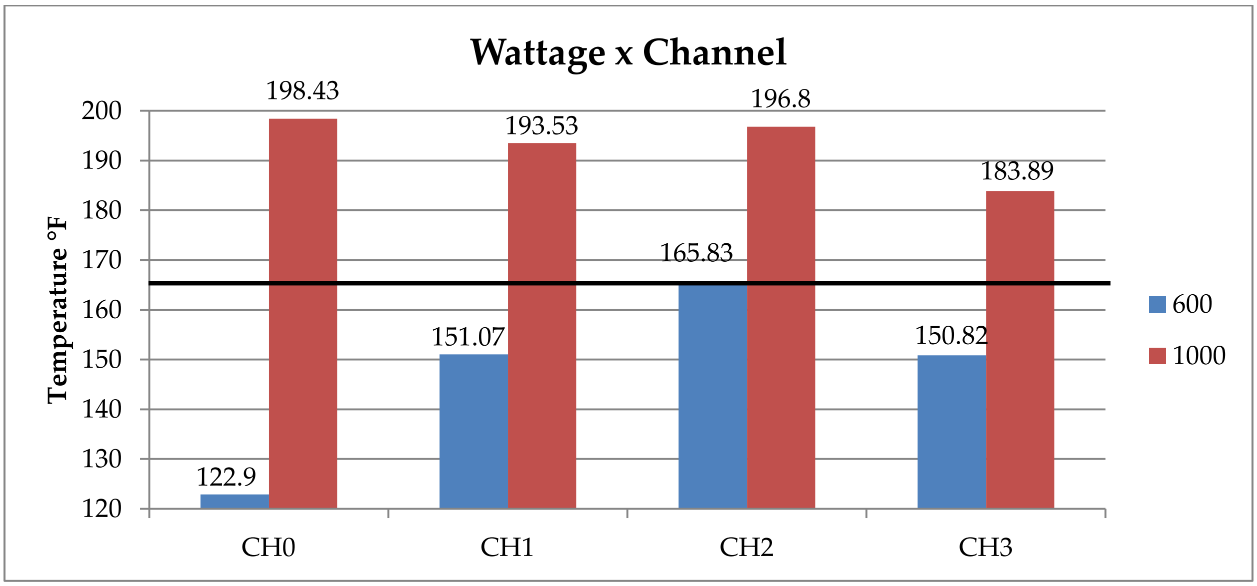


Figure 3.13: Plot of means for the significant Wattage x Channel interaction when multiple product units were prepared in a microwave oven.

Channel designations: Ch0 = inserted into center filling, Ch1 and Ch3 = inserted ¼" into chicken, Ch2 = inserted ½" into chicken; Wattage = 600W and 1000W; Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); n=5; p-value <.0001.

Figure 3.13 illustrates the average end-point product temperature when comparing each of the wattages used in the study (600W and 1000W) to cook the entrées. Again, entrées prepared in the 1000W microwave oven were of no food safety risk since all internal end temperatures exceeded 165°F (183.8°F to 198.43°F). In contrast, three of the four channels when prepared in a low wattage microwave oven failed to reach 165°F. Channel 2 was the only channel to reach a fully cooked end-point temperature of 165.83°F. However, the SE for this interaction was 2.75; therefore, temperatures at channel 2, when prepared again, may range from approximately 163.08°F to 168.58°F. However, regardless if channel 2 achieves a safe end-point temperature, the remaining three channels failed to reach a safe end temperature thereby resulting in an unsafe entrée. In contrast to the Wattage x Channel interaction plot for a single product unit (Figure 3.4), the center of the entrée reached only 122.9°F. The discrepancy in heating pattern for the center of the entrée may be the result of increased product mass in the microwave cavity. As the product mass increases the microwaves start to distribute unevenly throughout the entrée ultimately giving rise to hot and cold spots. However, if consumers did follow manufacturers recommendations and take the internal temperature reading of the entrée in the thickest location (the center) they would be aware that additional time was needed to achieve a fully cooked entrée as indicated by the average end-point temperature achieved on channel 0 - 122.9°F.

Figure 3.14 illustrates the average end-point temperature when examining product and wattage on a by-channel basis. As mentioned previously, entrées prepared in a 1000W microwave oven reached temperatures greater than the recommended 165°F

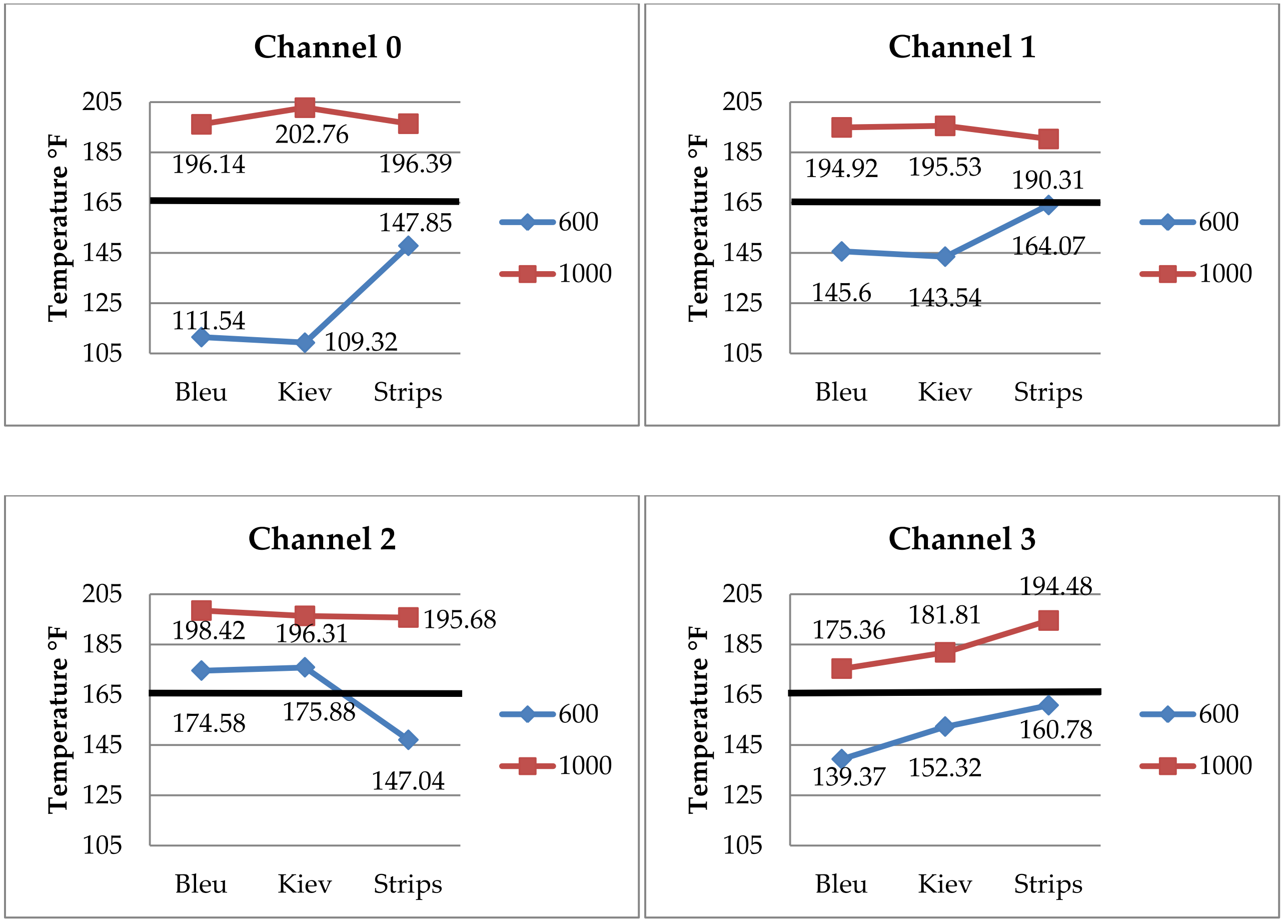


Figure 3.14: Plot of means for the significant Product x Wattage x Channel interaction observed when multiple product units were cooked in a microwave oven.

Channel designations: Ch0 = inserted into center filling, Ch1 and Ch3 = inserted ¼" into chicken, Ch2 = inserted ½" into chicken; Wattage = 600W and 1000W; Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); n=5; p-value <.0001.

and therefore were not consider a food safety risk. In contrast, entrées prepared in a 600W microwave oven were often undercooked. Both stuffed entrées, CCB and CK, failed to reach a safe end-point temperature on channels 0, 1, and 3. However, both entrées were fully cooked at channel 2. In contrast, CS were undercooked on all channels.

Analysis of minimum mean product temperatures when comparing a single product unit and multiple product units

Evaluation of the entrée as a whole: Averaging temperature over all channels

Table 3.7 contains the F-test p-values and Table 3.8 contains the main effect means plus standard errors for the analysis of minimum mean end-point temperatures achieved when microwave cooking of single versus multiple product units (SM), respectively. Whole plot analysis averages temperature over all channels. Of the 31 interactions evaluated in the analysis of multiples and singles together, seven were significant ($p \leq 0.05$) and will be discussed below. The discussion will begin with one-of-two significant three-way interactions, specifically, SM x Flip x Wattage (Figure 3.15). From this interaction, three two-way interactions can be extracted; however, only two were significant, SM x Wattage (Figure 3.16) and SM x Flip (Figure 3.17). A second three-way interaction, SM x Product x Cover (Figure 3.18, was also significant. When broken down into three two-way interactions, only one was found to be significant, SM x Product (Figure 3.19). Figure 3.15 details the three-way interaction occurring among

Table 3.8: F-test p-values[1] with Minimum Temperatures for the Analysis of frozen breaded chicken entrées cooked as single and multiple units

	F Test p-values				
	Channels Analyzed Separately				Channel as a factor
	Min0	Min1	Min2	Min3	Min[7]
SM	<.0001	0.6480	<.0001	0.6085	0.3893
Product	0.0042	0.5799	0.0611	0.0003	0.0014
SM*Product	0.0214	0.7029	0.0462	0.2968	0.0446
Flip	0.2840	0.5455	0.1079	0.0029	0.2543
SM*Flip	0.0273	0.0274	0.0034	0.0518	0.0205
Product*Flip	0.0637	0.5242	0.1395	0.2646	0.3035
SM*Product*Flip	0.2109	0.8197	0.0686	0.4760	0.4117
Cover	0.2275	0.9343	0.2045	0.3754	0.5048
SM*Cover	0.1694	0.9332	0.2080	0.8918	0.2914
Product*Cover	0.0317	0.3106	0.7160	0.5645	0.7374
SM*Product*Cover	0.0057	0.1602	0.0837	0.2413	0.0027
Flip*Cover	0.0062	0.9130	0.3523	0.9680	0.4177
SM*Flip*Cover	0.7320	0.5734	0.2419	0.0719	0.1817
Product*Flip*Cover	0.2003	0.0747	0.0578	0.3969	0.0751
Wattage	<.0001	<.0001	<.0001	<.0001	<.0001
SM*Wattage	<.0001	0.0503	<.0001	0.3288	0.0016
Product*Wattage	0.1388	0.6910	0.7365	0.0278	0.8141
SM*Product*Wattage	0.7620	0.9373	0.8533	0.1828	0.7422
Flip*Wattage	0.3143	0.6213	0.0101	0.3722	0.4904
SM*Flip*Wattage	0.0151	0.0055	0.0006	0.3261	0.0010
Product*Flip*Wattage	0.0104	0.8428	0.2837	0.5179	0.2782
Cover*Wattage	0.6801	0.6565	0.0851	0.3556	0.2781
SM*Cover*Wattage	0.5507	0.4472	0.1955	0.8552	0.2323
Product*Cover*Wattage	0.2980	0.8309	0.5403	0.3676	0.3367
Flip*Cover*Wattage	0.5548	0.3645	0.5814	0.4217	0.8832

[1] p-values highlighted in grey are significant ($p \leq 0.05$).
[2] Only Chicken Cordon Bleu and Chicken Kiev were cooked as a single product unit.
[3] Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time.
[4] Covering was achieved by using a plastic microwave safe covering during the recommended cooking time.
[5] Two wattage of microwave ovens were used – 600W and 1000W
[6] Channel designations: Ch0 inserted into center filling, Ch1 and Ch3 inserted ¼" into chicken, Ch2 inserted ½" into chicken.
[7] Min = minimum end-point temperature observed on each channel.

Table 3.5: Continued

		Channel as a factor
		Min
Channel[2]		<.0001
Channel*SM		<.0001
Channel*Product		0.0087
Channel*SM*Product		0.1877
Channel*Flip		0.0074
Channel*SM*Flip		0.0011
Channel*Product*Flip		0.1046
Channel*Cover		0.3550
Channel*SM*Cover		0.5996
Channel*Product*Cover		0.0704
Channel*Flip*Cover		0.0383
Channel*Wattage		0.0038
Channel*SM*Wattage		<.0001
Channel*Product*Wattage		0.0448
Channel*Flip*Wattage		0.0581
Channel*Cover*Wattage		0.5278

[1] p-values highlighted in grey are significant ($p \leq 0.05$).
[2] Only Chicken Cordon Bleu and Chicken Kiev were cooked as a single product unit.
[3] Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time.
[4] Covering was achieved by using a plastic microwave safe covering during the recommended cooking time.
[5] Two wattage of microwave ovens were used – 600W and 1000W
[6]Channel designations: Ch0 inserted into center filling, Ch1 and Ch3 inserted ¼" into chicken, Ch2 inserted ½" into chicken.
[7]Min = minimum end-point temperature observed on each channel.

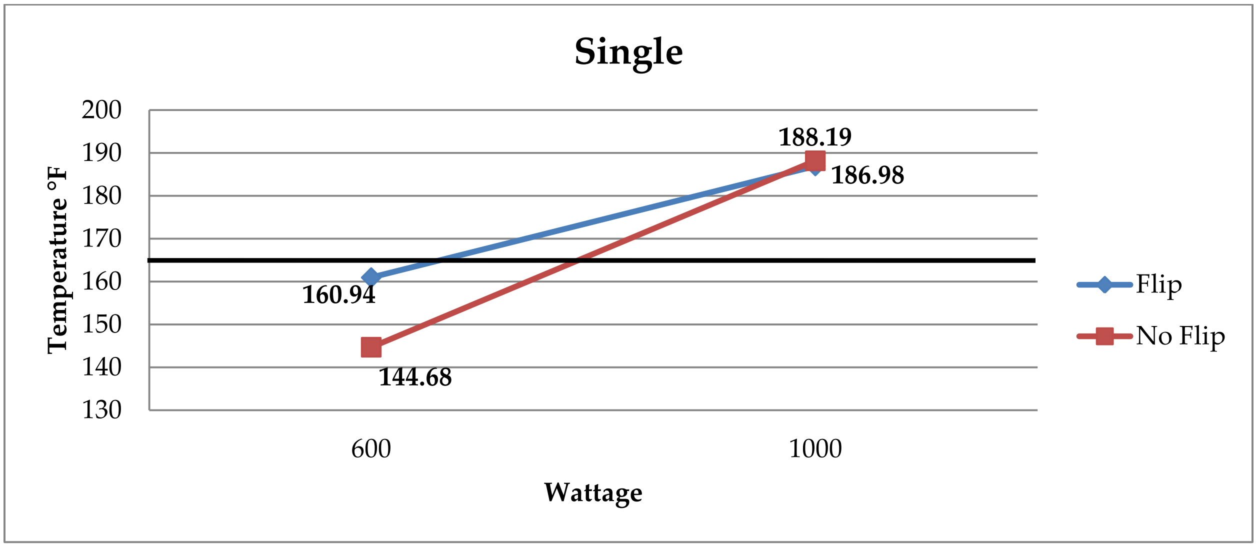
Table 3.9: Minimum end-point temperature means with standard errors for the analysis of frozen, breaded chicken entrées cooked as a single unit and multiple product units in a microwave oven.

	Means with Standard Error (°F)				
	Single and Multiple Units By Channel[1]				Means Across Ch.[2]
SM	**0**	**1**	**2**	**3**	**Min**
Multiples	155	170	186	162	168
Singles	180	168	168	164	170
Standard Error	2.64	2.97	2.31	2.59	1.52
PRODUCT					
Bleu	162	170	174	156	a[3] 166
CK	173	168	180	170	b 173
Standard Error	2.64	2.97	2.31	2.59	1.52
FLIP					
Flip	166	168	180	169	171
No Flip	170	170	175	158	168
Standard Error	2.64	2.97	2.31	2.59	1.52
COVER					
Cover	165	169	175	165	169
No Cover	170	169	179	162	170
Standard Error	2.64	2.97	2.31	2.59	1.52
WATTAGE					
W1000	194	190	195	181	a 190
W600	142	148	159	145	b 148
Standard Error	2.64	2.97	2.31	2.59	1.52
CHANNEL					
0					a 168
1					a 169
2					b 177
3					a163
Standard Error					1.86

[1]Channel designations: Ch0 inserted into center filling, Ch1 and Ch3 inserted ¼″ into chicken, Ch2 inserted ½″ into chicken.

[2]End-point temperatures for a single unit averaged over all channels.

[3]Different letters (a,b) indicate that mean minimum temperatures recorded across recording channels are different ($p \leq 0.05$).



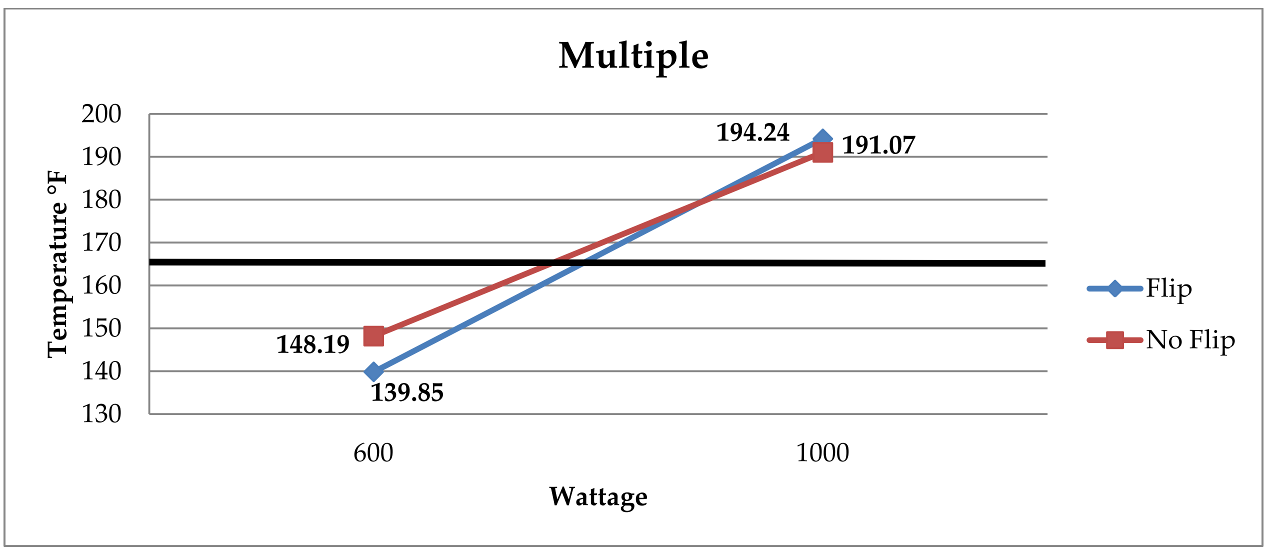


Figure 3.15: Plot of means for significant SM x Flip x Wattage interaction when a single product unit and multiple product units were both cooked in a microwave oven.

Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time; Single Product Unit = chicken cordon bleu/chicken kiev, Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); Wattage = 600W, 1000W; n=5; p-value .0001.

SM x Wattage x Flip. When prepared in a 1000W microwave oven no difference in end-point temperatures were observed when the entrées were flipped versus not flipped. Furthermore, all end products could be considered overcooked as end-point temperatures surpassed 165°F by approximately 25°F. In contrast, all entrées prepared in the 600W microwave oven were undercooked regardless of whether they were cooked individually or in multiples. However, when cooked individually and per manufacturer's instructions (flipped), the end temperature was within 5°F of 165°F. All other combinations of flipping for a single product unit or multiple product units cooked in a 600W microwave oven resulted in the end-point temperatures >15°F below the 165°F target. The SE for SM x Flip x Wattage was 3.05. As a result, the confidence interval (154.84°F to 167.04°F) contained temperatures greater than 165°F. Therefore, if prepared again under like conditions end temperatures may result in a safe end product.

Consumers are instructed to increase cooking time when preparing more than one entrée at a time. However, even with the additional cooking time entrées remained undercooked. Flipping had a different impact on end-point temperature when products were cooked individually versus in multiple product units. When cooked individually, flipping increased end-point temperature; however, when cooked as multiples it decreased internal temperature. Regardless of whether these particular frozen raw breaded chicken entrées were cooked individually or as multiples, flipped or not flipped, all end-point temperatures failed to reach a 165°F in a 600W microwave oven thereby posing a significant food safety risk.

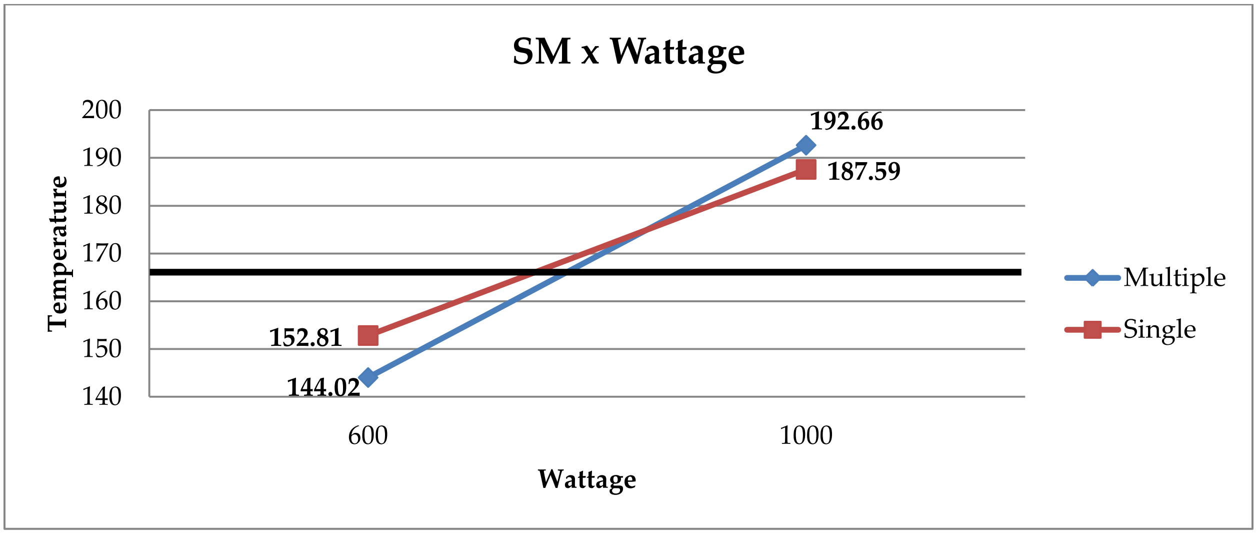


Figure 3.16: Plot of means for the significant SM x Wattage interaction when a single product unit and multiple product units were both cooked in a microwave oven.

Single Product Unit = chicken cordon bleu/chicken kiev, Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); Wattage = 600W, 1000W; n=5; p-value .0016.

The three-way interaction discussed above can be broken down into three two-way interactions of which only two [SM x Wattage (Figure 3.16) and SM x Flip (Figure 3.17)] were significant. Similar to SM x Flip x Wattage, entrées were fully cooked in a 1000W microwave oven and of no food safety risk; however, all entrées were uncooked when prepared in a 600W microwave oven. End-point temperatures across products, when prepared in the lower wattage oven, were on average 12-21°F below the recommended safe internal temperature. In contrast, entrées prepared in the 1000W microwave reached end temperatures approximately 22°F above 165°F.

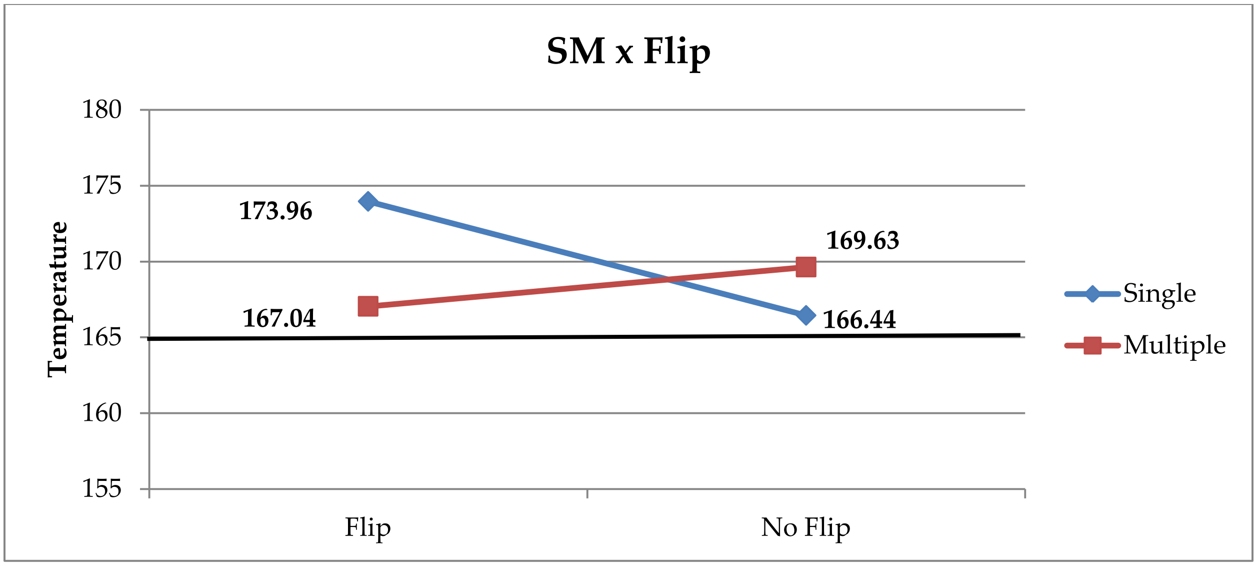


Figure 3.17: Plot of means for the significant SM x Flip interaction when a single product unit and multiple product units were both cooked in a microwave oven.

Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time; Single Product Unit = chicken cordon bleu/chicken kiev, Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); Wattage = 600W, 1000W; n=5; p-value .0016.

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When looking at the three-way interaction, all entrées, regardless if cooked individually or in multiples, were not fully cooked when flipped. Figure 3.17 details the impact flipping had on end temperature when wattage was not considered. Entrées were fully cooked when flipped as well as not flipped. However, end temperatures closer to 165°F conserve the qualities of the entrée (moisture, flavor, etc). End temperatures were closest to 165°F when not flipped (single) and flipped (multiples).

In addition to flipping, consumers are instructed to cover entrées during microwaving. Figure 3.18 illustrates the interaction between SM x Product x Cover.

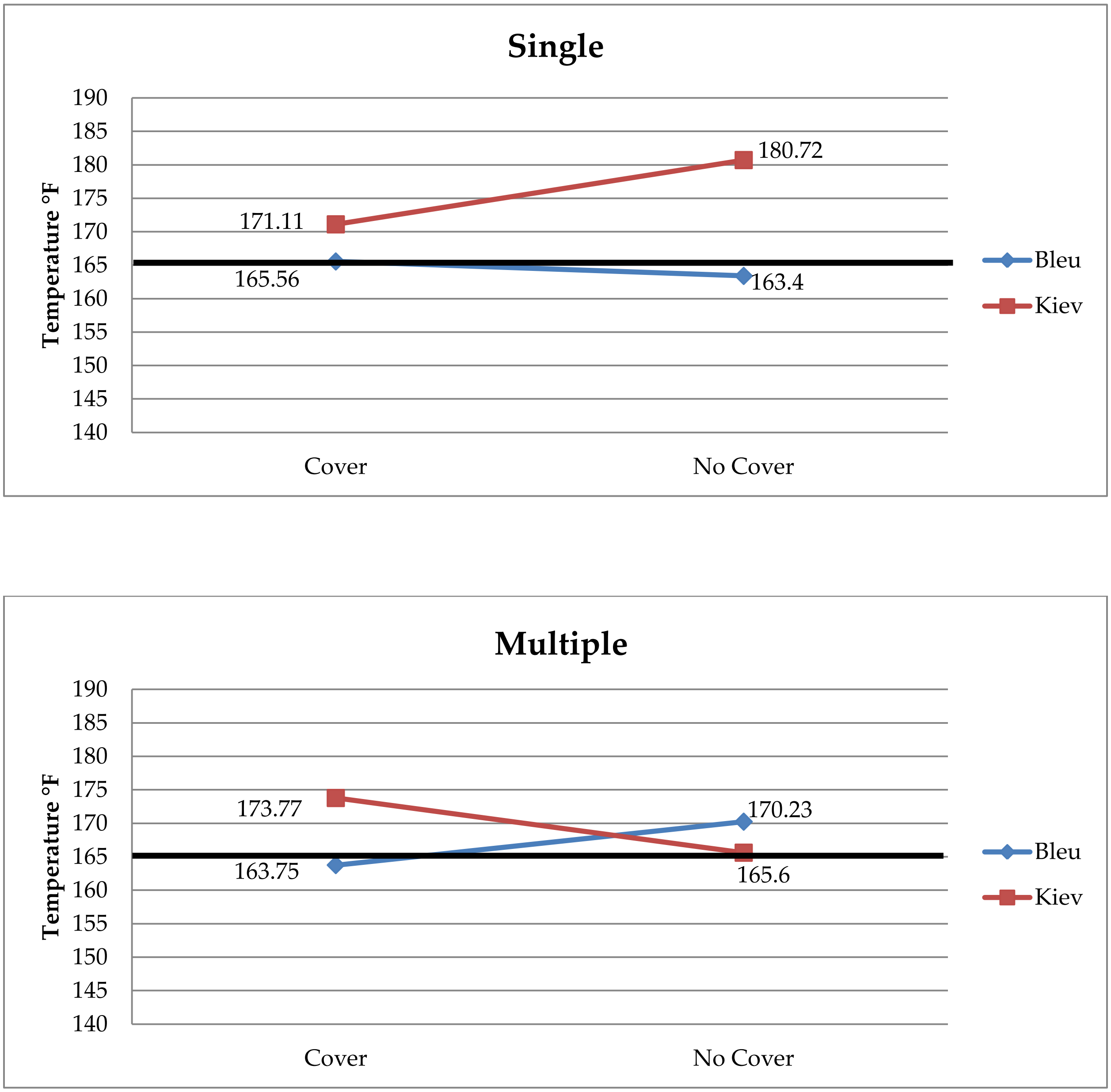

Figure 3.18: Plot of means for the significant SM x Product x Cover interaction when a single product unit and multiple product units were both cooked in a microwave oven.

Covering was achieved by using a plastic microwave safe covering during the recommended cooking time; Single Product Unit = chicken cordon bleu/chicken kiev, Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); n=5; p-value .0027.

When prepared per the manufacturer's instructions, CK was fully cooked when prepared individually as well as two at a time. Furthermore, there was no difference in end-point temperature observed when cooking single versus multiple CK products units covered (171.11°F versus 173.77°F). However, when uncovered there was approximately a 15°F difference in end-point temperature when CK were cooked individually (180.72°F) and in multiples (165.6°F).

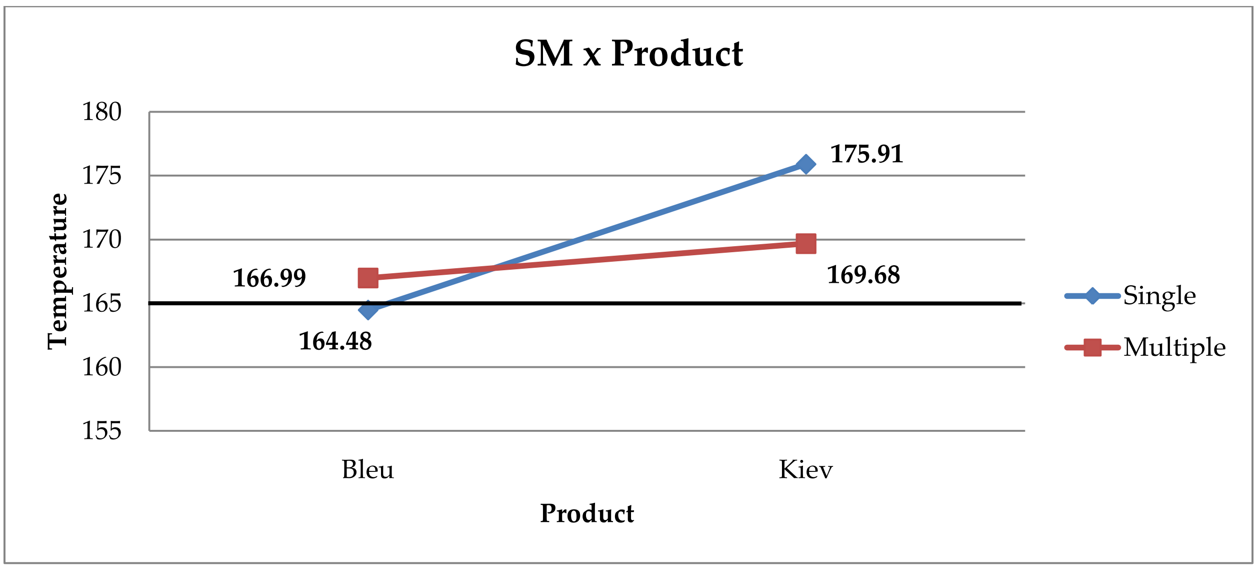

Figure 3.19: Plot of means for the significant SM x Product interaction when a single product unit and multiple product units were both cooked in a microwave oven.

Single Product Unit = chicken cordon bleu/chicken kiev, Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); n=5; p-value .0446.

In contrast, when prepared individually, CCB was fully cooked (165.56°F) when covered, but was very slightly undercooked when uncovered (163.40°F). The opposite was observed when CCB were cooked as multiple units. The entrées were fully cooked

(170.23°F) when uncovered, but when prepared per the manufacturer's instructions specifying use of a cover, they were slightly undercooked (163.75°F). A single recommendation should again not be provided on similar entrées as a safe end product does not always result.

Figure 3.19 details the two-way interaction SM x Product. The end-point temperature for CK exceeded 165°F when prepared both individually (175.91°F) and in multiple product units (160.68°F). In contrast, a significant difference in end-point temperature was not observed for CCB whether cooked as singles or multiples. CCB was fully cooked when prepared two at a time (166.99°F), but failed to reach a safe end-point temperature when prepared individually (164.68°F). The confidence interval (160.17°F to 168.79°F) contained temperatures greater than the recommended safe end temperature for poultry. As a result, the potential exists for a fully cooked entrée to result if prepared under like conditions.

Evaluation of channels: The effect of channel (temperature probe placement) and its interaction with other treatment factors

The discussion will begin with one-of-four three-way interactions, specifically, Product x Channel x Wattage (Figure 3.20). From this interaction, two significant two-way interactions, Wattage x Channel (Figure 3.21) and Product x Channel (Figure 3.22), can be extracted. The second three-way interaction, SM x Wattage x Channel (Figure 3.23), will then be discussed. From the second three-way interaction, SM x Channel

(Figure 3.24) can be analyzed. The final three-way interaction discussed will be Channel x SM x Flip (Figure 3.25).

Figure 3.20 details the three-way interaction Channel x Wattage x Product. As mentioned with the other analyses, entrées prepared in a 1000W microwave oven were not of a food safety risk as all end temperatures reached 165°F. In contrast, when prepared in a 600W microwave oven, all channels regardless of the product prepared, failed to reach 165°F. The highest temperature recorded within the CCB was 155.7°F from channel 2 and internal product temperatures ranged from 134.1°F to 155.7°F (a 21.6°F difference in temperature throughout the product). Similarly, there was a difference of 18°F when comparing the highest and lowest temperatures for the CK (144.25°F to 162.96°F). When directly comparing end-point temperatures within the products, CK achieved a higher temperature on three of the four channels. Channel 1 was the only channel in which CCB had a slightly higher end-point temperature than CK. Overall, a predictive cold spot could not be determined as all channels consistently failed to reach 165°F thereby creating a food safety risk when the entrées when were prepared in a 600W microwave oven.

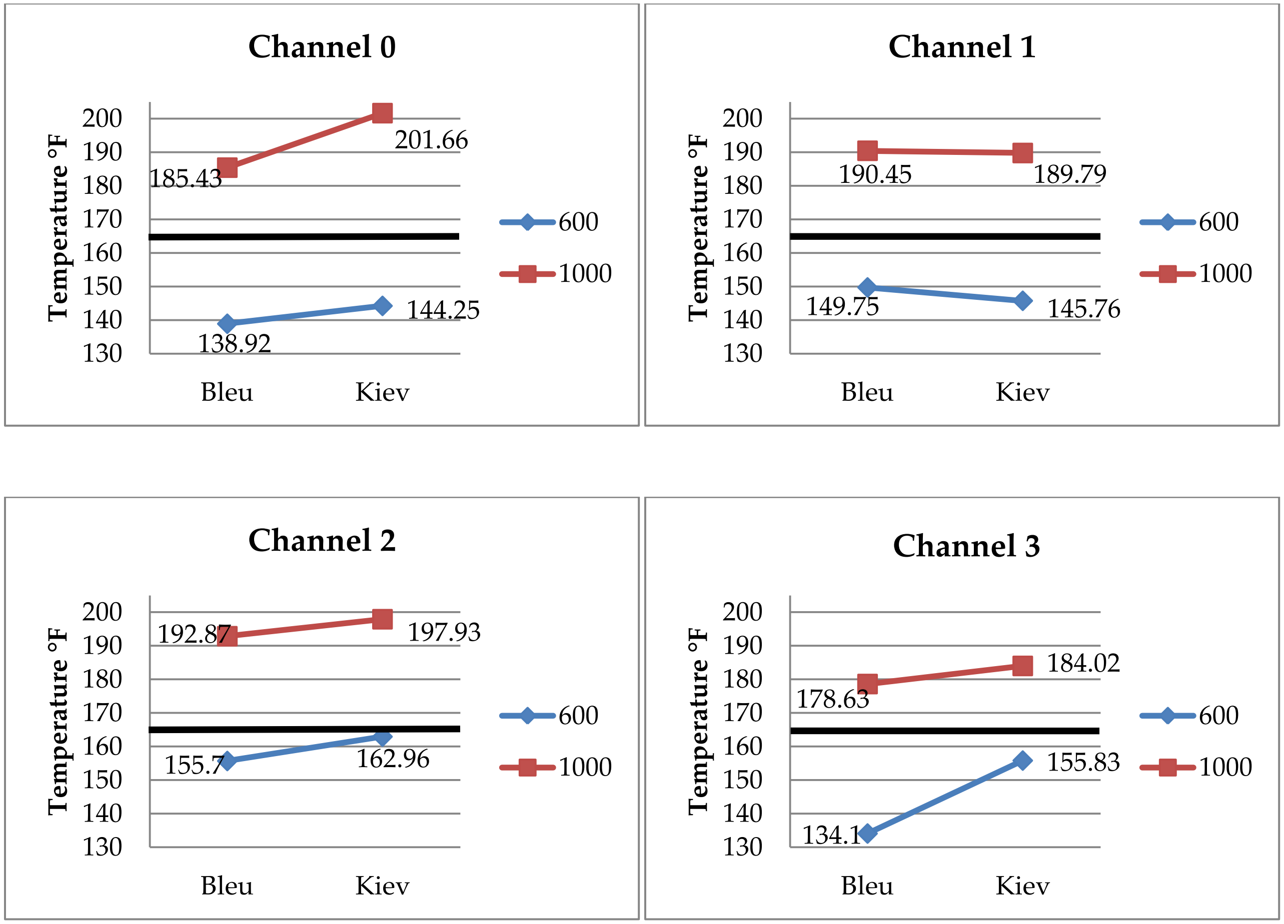

Figure 3.20: Plot of means for the significant Product x Wattage x Channel interaction observed when a single product unit and multiple product units were both cooked in a microwave oven.

Channel designations: Ch0 = inserted into center filling, Ch1 and Ch3 = inserted ¼″ into chicken, Ch2 = inserted ½″ into chicken; Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); Wattage = 600W, 1000W; n=5; p-value 0.0448.

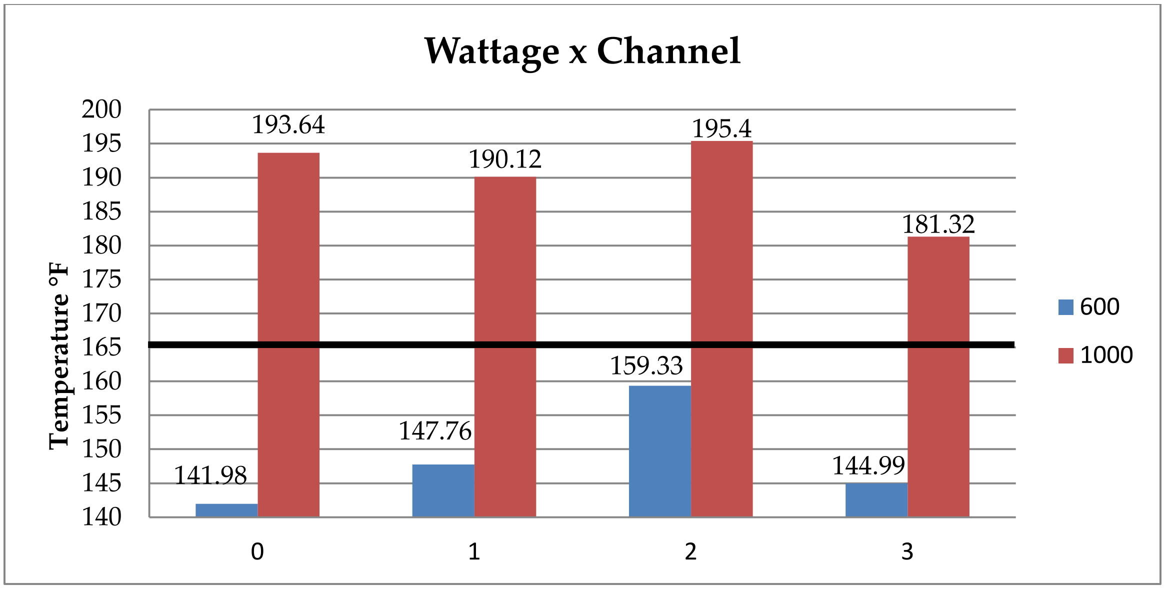

Figure 3.21: Plot of means for the significant Wattage x Channel interaction observed when a single product unit and multiple product units were both cooked in a microwave oven.

Channel designations: Ch0 = inserted into center filling, Ch1 and Ch3 = inserted ¼″ into chicken, Ch2 = inserted ½″ into chicken; Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); Wattage = 600W, 1000W; n=5; p-value 0.0038.

Similar to all other interactions including wattage, all channels when prepared in a 1000W microwave oven were not a food safety risk as end temperatures exceeded 165°F by an average of 25 °F (Figure 3.21). In contrast, all channels when prepared in a 600W microwave oven were undercooked. Moreover, end-point temperatures were as much as 23°F below the 165°F target. Overall, NRTE entrées should not be prepared in a lower wattage microwave oven unless further validated cooking directions can be established for each individual product.

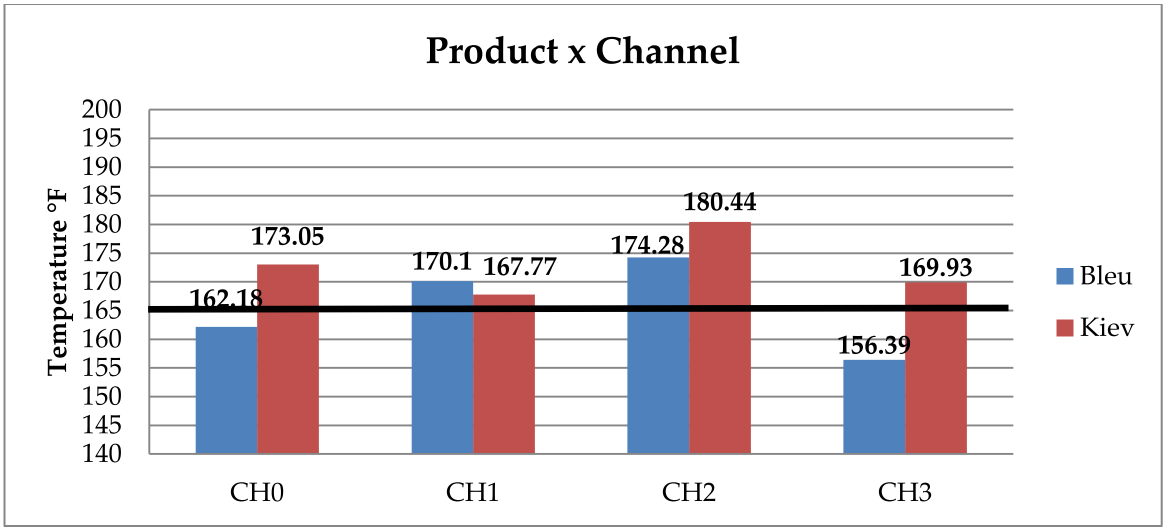

Figure 3.22: Plot of means for the significant Product x Channel interaction observed when a single product unit and multiple product units were both cooked in a microwave oven.

Channel designations: Ch0 = inserted into center filling, Ch1 and Ch3 = inserted ¼″ into chicken, Ch2 = inserted ½″ into chicken; Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); n=5; p-value 0.0038.

Manufacturers must determine the heating pattern that occurs throughout an entrée when instructions are applied correctly in order to establish if a blanket set of cooking instructions can be applied to similar products within a given product category (i.e., stuffed entrées within the product category frozen NRTE breaded chicken products). If validated instructions are implemented correctly, a safe end product should result. When wattage is not considered, Chicken Kiev, on all channels, reached a safe end-point temperature, but CCB only reached a safe internal temperature on two channels (Channels 1 and 2). When looking at temperature distribution within each product, a more even distribution of heat was observed within CK as there was only a

10.5°F difference from the highest temperature to the lowest temperature compared to the 18°F difference observed within CCB. Based on the data, an undercooked entrée should result each time the entrée is prepared. The upper limit of the confidence interval (SE = 2.64) for CCB on Channel 3 did not contain temperatures that exceeded 165°F. While CK was fully cooked, the lower limit of the confidence intervals on Channel 1 (162.5 to 173.04) and Channel 3 (164.66 to 175.2) did contain temperatures less than 165F; therefore, the potential exists when prepared again that the entrée will not reach a safe end-point temperature on all channels. Figure 3.23 details the three-way interaction between SM x Wattage x Channel. Similar to other interactions examining wattage, all entrées prepared, regardless of whether cooked individually or in multiple units, were fully cooked in a 1000W microwave oven and therefore were not considered a food safety risk. Therefore, the following discussion will only apply to entrées prepared in a 600W microwave oven. When prepared individually, a safe end-point temperature was reached only on Channel 0. The internal temperatures on the remaining three channels were below 165°F (as low as 143.42°F). When cooked as multiple units, cooking time recommendations are generally increased. Even with the additional cooking time suggested by the manufacturer's label, entrées failed to reach a safe end temperature on three of the four channels.

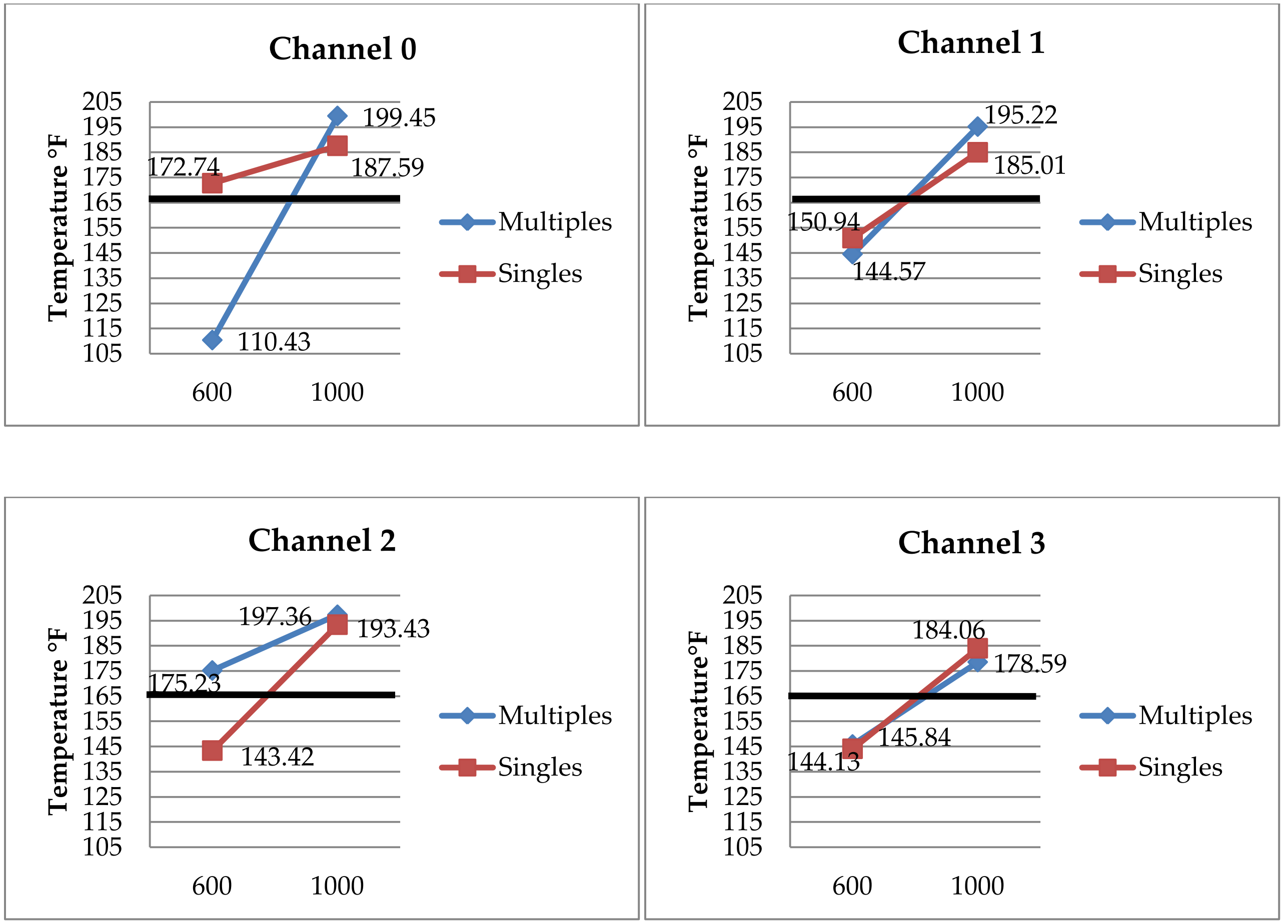

Figure 3.23: Plot of means for the significant SM x Wattage x Channel interaction observed when a single product unit and multiple product units were both cooked in a microwave oven.

Channel designations: Ch0 = inserted into center filling, Ch1 and Ch3 = inserted ¼″ into chicken, Ch2 = inserted ½″ into chicken; Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); Wattage = 600W, 1000W; n=5; p-value 0.0087.

In contrast to when prepared individually, entrées were only fully cooked on Channel 2 reaching an internal temperature of 175.23°F. The range of temperatures within the entrées cooked in multiples in the 600W was 110.43 to 175.23°F —a 64°F difference of temperature throughout the entrée. In comparison, when cooked individually, a 29°F difference in end-point temperature was observed. Regardless of whether prepared individually or in multiples, heating was not uniform and varied widely when prepared in a lower wattage microwave oven.

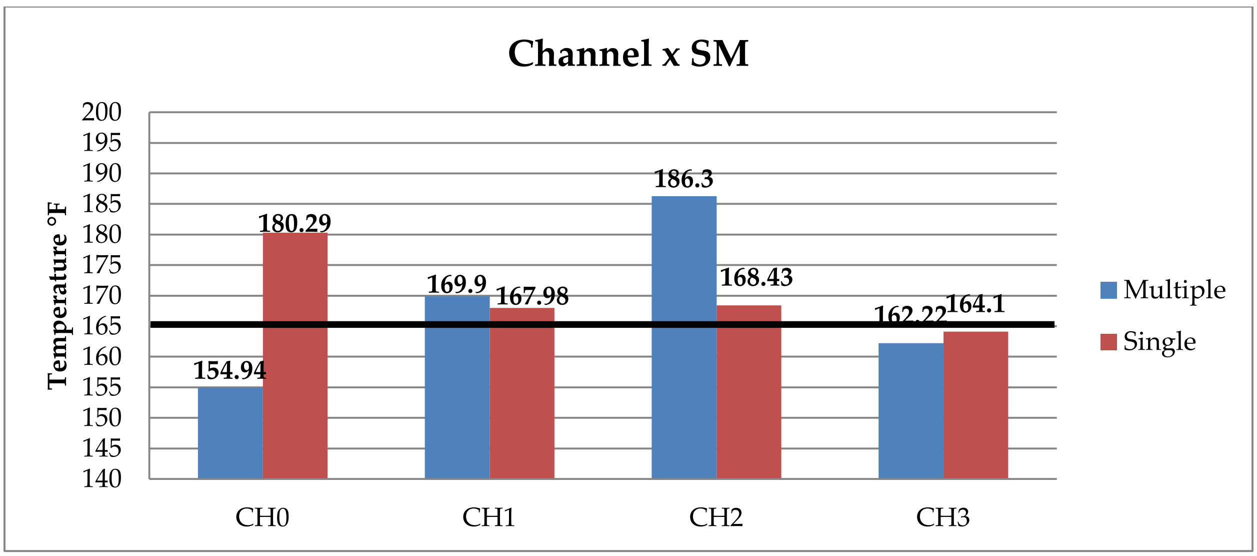

Figure 3.24: Plot of means for the significant SM x Wattage x Channel interaction observed when a single product unit and multiple product units were both cooked in a microwave oven.

Channel designations: Ch0 = inserted into center filling, Ch1 and Ch3 = inserted ¼″ into chicken, Ch2 = inserted ½″ into chicken; Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); n=5; p-value <.0001.

Figure 3.24 details the two-way interaction between SM x Channel. Breaking down end-point temperature by channels helps determine the uniformity of temperature distribution. Regardless if prepared individually or in multiples, one channel reached an end-point temperature higher than the remaining three channels. When products were cooked as single units, Channel 0 achieved an end-point temperature approximately 12-19°F greater than the other channels. When products were prepared two at a time, the highest temperature was recorded on Channel 2 with temperatures at the other three probe locations ranging from 154.94°F – 167.98°F. There was a 31 degree difference between the highest temperature and lowest temperature within the entrées when cooked as multiple units. Overall, a more uniform heating pattern was observed when CCB and CK were prepared individually; however, not all channels reached a safe end-point temperature. The SE for this interaction was 2.64 meaning the confidence interval contained temperatures that could result in a safe end product. Therefore, when prepared again, it is possible that all channels may achieve an end temperature that would be safe for consumption. When cooked as multiple product units, two of the four channels failed to reach 165°F. The potential does exist for Channel 3 to reach a safe end temperature as the upper limit of the confidence interval for this data point (156.95°F to 167.49°F) exceeded 165°F. However, the confidence interval for channel 0 does not contain a safe end temperature (149.67°F to 160.21°F).

The final analysis examined singles and multiples together. Figure 3.25 breaks down by channel the effect flipping and cooking of the entrées individually or in multiples had on end-point temperature for each channel. All channels, when cooked individually and flipped, reached a safe internal temperature. However, the lower limit of the confidence interval for channel 3 (155.99°F to 172.15°F) contained temperatures below 165°F. Therefore, when prepared under like conditions the potential exists for end-point temperature to fall below the necessary 165°F needed to ensure the overall safety of the product. In contrast, when cooked as multiple units, a safe end-point temperature was reached on two of the four channels. Furthermore, a higher internal temperature was reached on three of the four channels when not flipped. Of those channels, two reached a safe end temperature. Overall, when not considering wattage, CCB and CK entrées should be cooked individually and flipped as heating was more uniform and temperatures exceeded 165°F resulting in a safe end product.

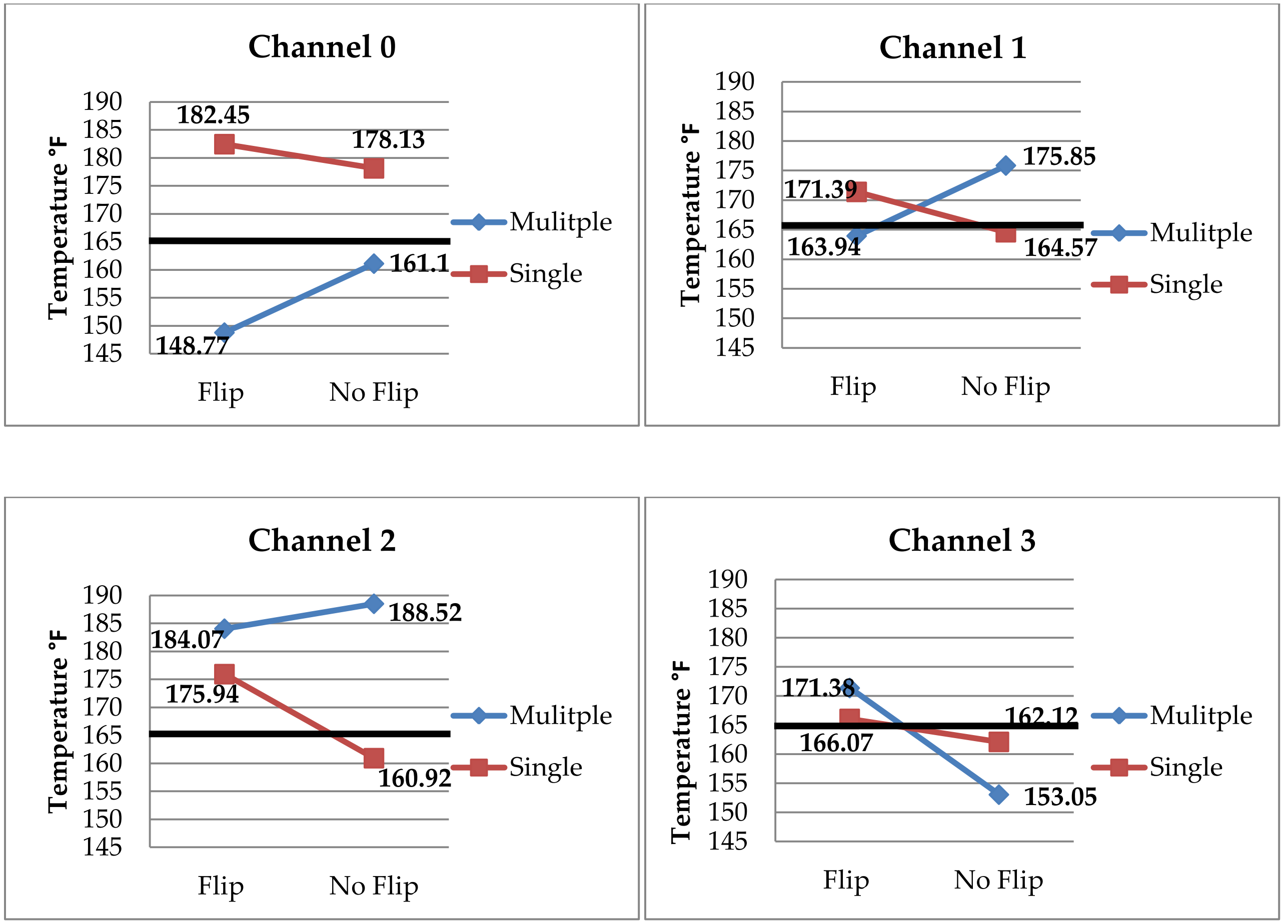

Figure 3.25: Plot of means for the significant SM x Flip x Channel interaction observed when a single product unit and multiple product units were both cooked in a microwave oven.

Flipping was achieved by quickly turning the entrée over at the mid-point of the recommended cooking time;Channel designations: Ch0 = inserted into center filling, Ch1 and Ch3 = inserted ¼" into chicken, Ch2 = inserted ½" into chicken; Multiple product units = 2 at a time (chicken cordon bleu/kiev) and 3 at a time (chicken strips); n=5; p-value 0.0383.

Discussion

This study was undertaken to experimentally determine if a safe end product can be consistently achieved when frozen, raw breaded chicken entrées are prepared per the manufacturer's microwave cooking instructions. The destruction of *Salmonella* in different food matrices, when heated within a microwave oven, has been the focus of several studies (Schnepf and Barbeau 1989; Heddleson and Doores 1994; Pucciarelli and Benassi 2005; Lihan and Sites 2010; Hollywood et al. 1991; Pepe et al. 2006). However, published studies have used experimentally inoculated food products with high levels of pathogenic organisms and therefore are not directly comparable to the results of the current non-inoculated study whereby end-point temperatures achieved across products were used to establish a target level of safety.

It should be noted that at the time of this study the microwave oven was commonly listed as an acceptable method of preparation of NRTE frozen, breaded chicken products. However, following the 2005-2006 outbreak of salmonellosis linked to raw, breaded stuffed poultry products, most manufacturers voluntarily eliminated microwave cooking instructions from the acceptable methods listed for preparation (Smith et al. 2008). Although microwave cooking instructions now have been removed from most raw, frozen, stuffed poultry entrées, other products that contain raw or partially cooked meat remain on the market with microwave cooking instructions. An example would be pot pies which were implicated in a salmonellosis outbreak in 2007 (Centers for Disease Control and Prevention 2008).

The low wattage microwave oven used in this study, and likely low-wattage ovens in general, was ineffective in producing a safe end product for these types of processed foods. Industry leaders in attendance at a symposiums on microwave cooking at the 2008 International Association of Food Protection conference claimed microwave ovens below 800W are no longer commonly available to consumers (Guzewich 2008). Contrary to their statements, low wattage microwave ovens (600W and 700W) are still available in retail with sales peaking in August of every year as young adults are moving to college. This wattage is ideal for college dormitories because universities restrict the size of the microwave students can have in their rooms in order to limit the power drawn from the university's electrical supply (Schiffman 2010). Likewise, as a result of the poor economy, low wattage microwave ovens appeal to consumers due to the inexpensive price of the unit (Schiffman 2010). While the price may be appealing, consumers most likely do not consider the food safety risks associated with entrées prepared in a low wattage (e.g., 600W) microwave oven.

Consistent with other studies, data from this study illustrates the inability of low-wattage microwave ovens to ensure a safe end product when cooking raw, frozen entrées (Lindsay et al. 1986; Schnepf and Barbeau 1989; Levre and Valentini 1998; Pucciarelli and Benassi 2005). In contrast, entrées prepared in a 1000W microwave oven were almost always fully cooked, and in most cases might be considered overcooked as indicated by high internal end-point temperatures. The average end-point temperatures of CCB when prepared five separate times per the manufacturer's instructions (flip and cover) were 104°F, 129°F, 162°F, 166°F, and 177°F when prepared in a low-wattage microwave oven. Based on the average end-point temperature observed, only two entrées were fully cooked. However, when examined on a by-channel basis, the entrée achieving a final average end-point temperature of 166°F was in reality undercooked as the temperatures on the four channels were 190°F, 162°F, 147°F, and 165°F. If following manufacturer's instructions to check the internal temperature in the thickest location consumers would be led to believe the entrée was fully cooked as the end-point temperature recorded at the center location exceeded the recommended 165°F by 25°F. The remaining three channels monitored the temperature of the actual raw chicken component and registered temperatures ≤ 165°F. Figure 3.3 again illustrates the need for manufacturers to recommend that consumers check the internal temperature in multiple locations.

A consumer following the provided instructions would have believed the entrée was fully cooked because a food thermometer would have registered an end-point temperature of 177.6°F. However, the highest temperature achieved on the remaining three channels was 150.94°F. Therefore, consumers would proceed to consume an undercooked entrée because the microwave oven used for preparation failed to cook the entrée evenly and to a uniformly safe internal temperature.

A difference of 73°F in end-point temperature was documented when CCB was prepared under the same conditions five separate times using a 600W microwave oven. The extreme range in final internal temperatures of a specific product highlights the ineffectiveness of the provided cooking instructions in reaching an end-point temperature of 165°F. Similar observations were made by Heddleson and Doores (1994) when they concluded that encouraging consumers to cook an entrée for a designated period of time was unsuccessful. They suggested that if manufacturers would provide a single end-point temperature target in place of the time and temperature combination currently listed a better assurance of safety could be achieved. While the proposed approach may increase the likelihood of a safe end product, it would place added responsibility upon consumers since they would be required to estimate the appropriate length of time needed to achieve a fully cooked entrée. Furthermore, the improved approach suggested by Heddleson and Doores (1994) decreases the intended convenience attached to such products since consumers would be required to enter a cooking time, let it cook, check the temperature (multiple times), and continue cooking if necessary. To determine the internal end-point temperature consumers would need to properly utilize a food thermometer. The data obtained during the observational study (Chapter 2) revealed clearly that almost all participants failed to use a food thermometer when preparing convenience type products. Without the use of a food thermometer consumers may rely on other approaches they deem adequate for determining doneness (e.g., visual cues, poking with a utensil, feeling the product surface, etc.). All of these means of determining doneness were observed in the current study (Chapter 2). These alternative approaches may in turn increase the risk of foodborne illness due to the consumption of an undercooked entrée.

Datta and Davidson (2001) explained the increase in internal temperature within an entrée during microwave cooking results in a decrease in absorption of microwaves. When this occurs, the center of the entrée may fail to achieve a safe end-point temperature due to the inability of microwaves to efficiently penetrate the entrée. The results of the present study do not support this observation. When stuffed entrées were prepared individually in a low wattage microwave oven the center of the entrée was the only portion to reach a safe end temperature. The discrepancy between studies may be attributed to the wattage of microwave oven used to prepare the product. Furthermore, the oval shape of the entrée may have played a role. Heddleson and Doores (1994) reported that the rounded shape of an entrée helps to focus the microwaves, which results in the middle of an entrée heating at a quicker rate than the remainder of the product.

Manufacturers, when developing cooking instructions, may create combinations of steps/actions they assume can be applied to all entrées within a given processing category (e.g., stuffed poultry products). As demonstrated throughout our study, applying a common set of instructions for stuffed entrées is ineffective. When the two entrées were prepared in a 600W microwave oven, only CK was fully cooked. However, while fully cooked, the overall quality of the CK entrée was compromised as a result of end-point temperatures commonly and substantially exceeding 165°F. Therefore, to obtain an entrée of both safety and desirable quality, each entrée should have a unique set of instructions. Instead of a manufacturer broadly recommending that consumers flip and cover an entrée during cooking, a set of instructions validated for a specific entrée needs to be stated. For instance, CCB should be flipped, but not covered while CK should not be flipped or covered. Manufacturers should recommend a set of instructions that when applied correctly results in a product with an end temperature at or slightly above 165°F. As the internal temperature begins to exceed 165°F, the overall quality of the cooked product may begin to decrease as evidenced by the inner appearance of the entrée. After the two-minute hold time was completed random entrées were cut into to visualize the inner portion of the entrée. Chicken kievs exceeding 165°F appeared dry as most of the center filling had seeped out on the paper plate holding the entrée. In response to an unacceptable end product, consumers may start to alter the cooking time in order to achieve a more acceptable (less over-cooked) result. In doing so, consumers begin to deviate from the validated instructions potentially putting them at risk for foodborne illness.

The Grocery Manufacturers Association recommends multiple microwave ovens spanning a range of wattages be used when completing validation studies (Grocery Manufacturer's Association 2008). Despite this recommendation, some manufacturers have chosen different approaches as evidenced by the statement provided on product packaging stating a specific wattage that was used to validate the cooking instructions. The instructions provided on product packaging for CS clearly stated that the cooking instructions were validated using a 600W microwave oven. When using a low wattage microwave oven, manufacturers make the assumption that if a safe end product results when prepared in a 600W microwave oven, then the instructions will be more than adequate to achieve a safe end product in an oven of greater wattage. However, end products will likely be significantly overcooked at higher wattages based on our observations. In contrast, the instructions for CK and CCB used in our studies were validated by the manufacturer using a 1000W microwave oven.

The results of this study demonstrate that entrées were fully cooked when prepared in the 1000W oven, but extremely undercooked when prepared in the 600W microwave oven. Manufacturers account for this possibility by placing the statement, "appliances vary, adjust times accordingly" on the label. In doing so, manufacturers are shifting the responsibility to consumers to determine the appropriate cooking time needed to achieve a safe end product. Similar observations were made by Heddleson and Doores (1994) who also reported the inability of a 600W microwave oven to fully cook an entrée. Similar end-point temperatures were observed (145.4°F compared to the 147.66°F) in the present study when examining wattage as an individual treatment factor in the analysis of multiple product units. Overall, the results of our study revealed that the approaches previously taken by many manufacturers of microwavable frozen, raw entrées to establish validated cooking instructions are mostly ineffective. Based on the data of our study, should manufacturers decide to again provide microwave cooking instructions under the recommended preparation methods, they need to develop and validate the instructions in low (600-800W), medium

(<800-1000), and high wattage (>1000) microwave ovens. This range of microwave ovens allows for the evaluation of intended instructions in multiple wattages that consumers may potentially use when preparing their products. This approach would better ensure that both safety and quality of the finished products are achieved using a range of microwave ovens.

There were limitations to the current microwave cooking study. Performance testing was not completed on the microwaves prior to the commencement of the study. The microwaves were used immediately after purchase from a local retailer. Therefore, it was assumed that both microwaves were operating at a power at or near the specifications listed on product packaging. Furthermore, there were only two different wattages of microwaves evaluated in this study. Therefore, the results cannot be generalized to all wattages of microwave ovens. Likewise, there were only four sections of the entrées monitored by thermocouples. It could be argued that the four locations may not have been representative of the temperature distribution throughout the whole entrée; however, the four probe locations provided a good snap-shot of the entire product internal temperature. The study could be repeated using a thermal imaging system that would allow one to capture the entire temperature distribution throughout the entrée after applying the suggested conditions. It may also be beneficial to repeat the study using a range of microwave oven wattages that would be representative of the variety of ovens found within consumers' homes.

It is a manufacturer's responsibility to provide cooking instructions that are clear, complete, and when implemented correctly, result in an end product characterized by a high level of safety and expected quality. When developing thermal processes for raw entrées intended for cooking in a microwave oven, manufacturers need to consider the following: 1) product (composition of stuffing, shape, size, etc), 2) device used for preparation (microwave oven, conventional oven, toaster oven, etc.), 3) consumer preparation practices (number of products prepared simultaneously, rotation of products during cooking, flipping during cooking, hold time, location of entrée within device), and 4) locations at which the minimum internal temperatures across the product will be measured. Consumers expect a safe product when they purchase an entrée from retail, even one that is NRTE. However, manufacturers have little control over consumers' actions when preparing their products. Therefore, the worst-case scenario (within practical reasoning) should be taken into consideration when developing cooking instructions. Furthermore, in the event that a consumer fails to fully follow the instructions a built-in margin of error should be established and included in the provided cooking recommendations.

Manufacturers should consider alternative means to ensure the overall safety of their products. One possible option is to offer only a fully cooked version of their entrée. While fully cooked entrées seem most logical there is resistance from industry leaders. The Vice President of Brand Marketing for Barber Foods Inc., explained that fully cooked entrées do not move as quickly as the raw version of the same product (Dvorozniak 2011). Furthermore, the production costs associated with making a fully cooked product increase the cost at which it can be offered to consumers. Instead, four prominent processors of stuffed poultry entrées feel that removing microwave cooking from the acceptable methods of preparation will decrease the number of consumers suffering from foodborne illness due to consuming an undercooked entrée prepared in a microwave oven. They assume that if the microwave oven is not listed on the label consumers will choose the conventional oven as it is the recommended method of cooking (Dvorozniak 2011). However, habitual behavior is difficult to break—meaning that a consumer who prepared a stuffed entrée in the past may continue to do so despite the lack of microwave cooking instruction or even label warning/suggestions specifically stating to not use the microwave oven as a method of cooking.

Overall, low wattage microwave ovens, when used for cooking NRTE entrées that contain raw poultry, do not produce a safe end product. The inability of the 600W microwave oven to produce safe end product can lead to the survival of pathogenic microorganisms within the entrée. The observed inconsistency in heating intensifies the importance of consumers using a tip sensitive thermometer to monitor the temperature in multiple locations. The extreme difference in end-point temperatures when stuffed entrées were prepared under the same conditions highlights the fact that cooking instructions should be developed and validated on a product-to-product basis. It is important for manufacturers to take the best approach to validating label instructions—using multiple wattages and creating a unique set of instructions for every entrée. In doing so, an end product will be marketed that is much safer thereby reducing the outbreaks of foodborne illness associated with prepared, NRTE entrées.

Chapter 4: Conclusions

In 1998, frozen NRTE entrées containing raw meat and poultry were added to the continually expanding list of confirmed vehicles for *Salmonella*. Since the index outbreak, multiple sporadic outbreaks involving these product types have been documented. The recognition of these products as a vehicle for foodborne illness has led to an increase in research focused on the risk factors identified in outbreak investigations. These included inadequate and/or confusing labeling, consumers' response to provided preparation instructions, and preparation of products in a microwave oven. This dissertation addressed each of the three risk factors through three separate studies:

1. Creation of a representative list of cooking instructions present on product labels at the start of the study (2008);
2. Examination of the level of consumer understanding of food handling instructions available on NRTE raw, breaded, prebrowned chicken entrées; and,
3. Validation that the on-package microwave cooking instructions present at the time of the study were adequate to ensure a safe end-product if performed properly by the consumer.

Key Findings

The survey of retail supermarkets in Northeast Kansas between 2006 and 2009 identified characteristics of NRTE products that may increase the risk of foodborne illness when a consumer prepares raw, breaded, prebrowned poultry entrées. Risk factors included: raw and fully cooked entrées shelved directly next to each other in the frozen foods display case, both fully cooked and raw products marketed in a similar manner and in similarly appearing packages, preparation instructions provided on packages that were complicated and confusing, statements encouraging thermometer use that blended in with other wording on the package, and marketing single-serve NRTE entrées packaged in cellophane wrapping that mimicked entrées intended for the microwave oven (e.g. burritos).

Having established these risk factors during the retail survey, a consumer observational study was conducted to verify the impact, if any, these risk factors had on consumers' preparation of frozen, raw breaded poultry products. The observational study revealed marked differences between self-reported and observed food safety behaviors across both groups of consumers. Many participants (73 percent) reported owning a food thermometer and some indicated (19.5 percent) using one when cooking raw, breaded chicken entrées. However, only five of 41 participants were observed measuring the final internal temperature with a food thermometer despite instructions on the product packaging to do so; only three used the thermometer correctly. Furthermore, many participants failed to wash their hands after handling the raw product leading to an increased risk of indirect cross-contamination in the kitchen. Finally, only a small percentage (24 percent) of participants were observed adhering to the cooking instructions on the product label suggesting that the instructions provided on raw, breaded chicken products may be unclear and confusing, or that these instructions do not influence the way consumers prepare these products.

The principles of the Health Belief Model may possibly explain the behaviors observed in the observational study. This model suggests an individual's behavior can be determined by their personal beliefs or perceptions about a disease. In the observational study, we observed consumers failure to implement safe food handling practices (i.e., food thermometer use, handwashing). It could be suggested that behaviors were not carried out because consumers did not perceive there was any threat of foodborne illness if they did not implement the recommended behaviors. Furthermore, the model states that consumers will alter their behavior if provided a reason to do so. It is possible that the educational material sent to all participants following the completion of the study will satisfy the fifth factor of the model-cues to action. The provided material may increase consumer's awareness of the importance of safe food handling and therefore begin to implement such practices during meal preparation.

Immediately after participating in the observational study, participants completed a written survey where they were asked to self-report various activities, information, and their understanding related to food safety. Data obtained from self-completed surveys provided a positive depiction of study participants' food safety knowledge and behaviors; however, the corresponding observational results showed that all participants implemented unsafe food handling practices that may lead to an increased risk of foodborne illness. All 41 participants failed to completely follow the safe handling instructions provided on product packaging. Adolescents committed more food handling errors during meal preparation than the adults. Finally, information provided on product labels did not sufficiently compel consumers to follow suggested safe preparation recommendations.

In the final study, thermal profiling of NRTE entrées revealed that preparation in a low wattage microwave oven does not lead to a safe end product regardless of whether the chicken entrées were prepared individually or in multiples. The oven wattages examined produced an entrée of unacceptable safety (600W) and quality (1000W). Chicken strips reached a safe end-point temperature more consistently than stuffed entrées in the 600W microwave oven suggesting a common set of cooking instructions across all product types is ineffective for all stuffed entrées. Manufacturers should instead develop instructions on a product-by-product basis. Furthermore, uniform heating was not achieved despite additional treatments of flipping and/or covering an entrée during cooking. The ineffectiveness of a low wattage microwave oven to provide an even distribution of heat increases the risk of pathogen survival within the entrée ultimately, leading to an increased risk of foodborne illness.

Future Research

Several critical topics were identified during this research that should be addressed through further research to comprehensively manage risks associated with in this large product category. Possible future research efforts include:

1) A repeat of the thermal profiling study. It is necessary to clearly understand how a difference in wattage impacts industry-validated product preparation instructions. The thermal profile study should be expanded to include multiple microwaves ranging from 600W up to 1200W. The range of microwaves would encompass all wattages found in consumers' kitchens. The examination of multiple wattages would help in broadly identifying how an increase in wattage impacts the overall heating pattern of specific products.
2) Repeat the thermal profiling study using an infrared camera to monitor temperatures across the entire food product. The approach taken in this dissertation was considered adequate as four thermocouples were used to record temperatures during the two minute post-cooking hold time. While informative, it did not allow for the observance of the entire temperature distribution throughout the entrée. An infrared camera would enable a

researcher to look at the full temperature distribution throughout the product and identify any predictive cold spots.

3) Examination of the difference in thermal properties of individual constituents in multi-component frozen entrées. For example, Chicken Cordon Bleu is made up of ham, cheese, and chicken whereas Chicken Kiev is made up of only chicken and a buttery garlic seasoning. The temperature required to raise each component one degree may vary thereby affecting the overall rate at which the entrée heats. Chicken Cordon Bleu throughout the study was the entrée most often undercooked. This may be due to the specific heat of the individual ingredients. Chicken Kiev may have a lower specific heat in comparison to the Cordon Bleu and therefore achieve a safe end-point temperature quicker. As a result, when the same parameters are applied, Chicken Kiev is overcooked while Cordon Bleu is undercooked. This examination would better define preparation schedules and handling information needed on product labels.

4) As demonstrated, observational studies (as opposed to self-report surveys) are necessary to evaluate the true effectiveness of warning statements provided on product packaging. Future studies should consider the use of consumer interventions to modify safe food handling behaviors as evaluated by direct observation. This may include studying modified labels to

determine how and whether clearer label instructions and/or warning statements can generate a stronger adherence by consumers to provided instructions. Further studies of this nature may also be undertaken to lead to the creation of effective interventions to encourage safe food handling by young meal preparers in particular.

The strength of this project lies in the combination of controlled laboratory cooking studies using common consumer microwave cooking methods with a study that allowed direct observation of consumer behavior in a simulated home kitchen. The results generated were more accurate and allowed for an inclusive understanding of consumer/product risks. Risk factors associated with unclear or misinterpreted package labeling were identified during the observational study. In order to prevent future outbreaks, results from the studies suggest manufacturers of NRTE products should develop effective mechanisms to convey more compelling safe handling messages to a diverse population.

The product label is a simple yet informative way to present food safety information to consumers. However, manufacturers often fail to provide consumers food safety information in a captivating/compelling manner. Moreover, many consumers disregard the information commonly provided on a product label. Product labels should serve as a public health intervention meant to potentially prevent foodborne illness by compelling consumers to modify their personal behaviors.

Consumers are largely unaware of the extent to which their own behavior contributes to food safety or the measures needed to prevent foodborne illness in their home. The risk of foodborne illness can be reduced through a consumer's own behavior during food handling and preparation. Consumers should be aware of behaviors that could be implemented to lower their risk of foodborne illness during meal preparation (practice personal hygiene, cook food adequately, avoid cross-contamination, keep foods at safe temperatures, use a food thermometer etc.,). Food safety initiatives need to be developed to increase consumer's awareness of how to reduce the risks in the home. Educational materials already exist and are available through multiple media outlets (internet, magazines, television, etc). However, while accessible, consumers must want to utilize these sources to obtain food safety information. Most consumers believe themselves to be knowledgeable relative to food preparation and food safety; however, observed behavior highlighted significant and frequent gaps in their food safety knowledge. Improved food safety interventions should focus on specific groups instead of targeting the population as a whole. Adolescent food preparers are growing group of consumers and our study clearly demonstrated increased risky behaviors. To be effective, food safety education must increase a consumer's awareness about the risks and motivate them to change their current food handling practices. Food safety infosheets could be developed to target consumers. This approach is persuasive because the information provided within the messages depicts real-life situations to which individuals can personally relate. Food safety interventions should motivate consumers to alter their food handling behaviors to reduce the risk of foodborne illness during meal preparation.

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APPENDIX A: Recruitment Flyer

Kansas State University College of Veterinary Medicine

Diagnostic Medicine/Pathobiology

PARTICIPANTS NEEDED FOR FOOD QUALITY RESEARCH STUDY

Volunteers are needed for participation in a study evaluating quality concepts and preparation methods of a new food product.

Eligibility Criteria:

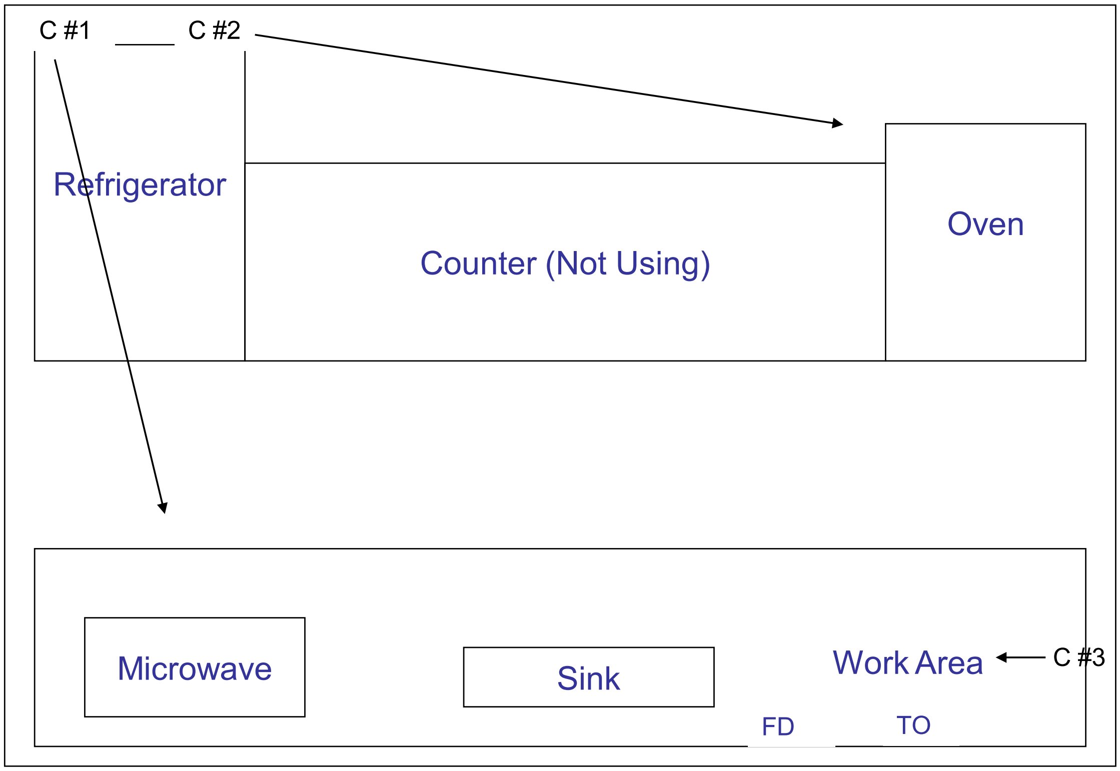
- Must be 10-16 years old OR the primary meal preparer in your household (prepare ≥ 2 meals /week)
- Must be available between June 11th - June 19th to participate on 1 occasion for between 60-90 mins
- Must be willing to be videotaped while preparing the new food product

All participants will receive $25 and a swag bag (including a t-shirt) for their time and effort. This study has been reviewed and authorized by the Kansas State University Committee for Research Involving Human Subjects.

If interested please contact Sarah DeDonder at (785) 532-3887 or sdedonde@vet.ksu.edu

APPENDIX B: Diagram of kitchen in Justin Hall

Justin Hall Room 115, Arrows denote camera angle, Computer, Camera #1 & 2 on top of fridge, #3 counter level



Camera #1: Capture behavior of individuals using the microwave; **Camera #2**: Capture behavior of the individuals using the oven; **Camera #3**: Capture behavior of the individual in the work area

FD = Fry Daddy; TO = Toaster Oven

APPENDIX C: Survey

Consumer Food Handling Survey

Opening Instructions
The answers you provide to the following questions are confidential and will be used for statistical purposes only. If you are uncomfortable with any of the questions, please feel free to skip them and go on with the rest of the questionnaire.

This study has been reviewed and approved by the Committee on Research Involving Human Subjects at Kansas State University. If you have any questions or concerns regarding your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact - anonymously, if you wish, the Institutional Review Board by calling (785) 532-3224 or e-mail: comply@ksu.edu.

Question 1

When purchasing food for your home, what is most important to you? Please rank the following food considerations with "1" being the most important and "7" being the least important.
______ Quality (freshness, taste/flavor)
______ Nutritional value
______ Price
______ Primary production (organic, genetically modified, animal welfare)
______ Food safety
______ Convenience
______ Other (____)

Question 2

Please rank the specific food handling behaviors you consider most important in preventing food poisoning with "1" being the most important and "6" being the least important.

______ Cleanliness (handwashing, sanitization of surfaces and kitchen equipment)
______ Separate raw and cooked foods
______ Cook foods thoroughly
______ Keep food at safe temperatures
______ Get food from safe sources
______ Other (____)

Question 3

Please consider the likelihood of the following by completing the statements:

1 - Very unlikely | 2 - Unlikely | 3 - Undecided | 4 - Likely
5 - Very Likely

	1	2	3	4	5
The likelihood of getting food poisoning from food prepared in the home is _______________.	◯	◯	◯	◯	◯
The likelihood of getting food poisoning from food prepared away from the home is _______________.	◯	◯	◯	◯	◯
The likelihood of giving MYSELF food poisoning because of the way I handle food is ________________.	◯	◯	◯	◯	◯
The likelihood of me causing OTHERS to get food poisoning because of the way I handle food is ________________.	◯	◯	◯	◯	◯
The likelihood of getting food poisoning from eating fresh fruits and vegetables is ________________.	◯	◯	◯	◯	◯
The likelihood of getting food poisoning from eating poultry is _____________________.	◯	◯	◯	◯	◯

Question 4

Have you ever heard of the microorganism *Salmonella* causing food poisoning? If yes, please proceed to Question 5. If no, please skip to Question 6.

◯ Yes

◯ No

Question 5

Do you remember what kinds of food were associated with the food poisoning that was caused by *Salmonella*? If yes, please list in the box below.

◯ Yes

◯ No

Question 6

Are you aware of any foodborne illness outbreaks that have resulted from the consumption of raw breaded chicken products? If yes, please describe what you remember about the outbreak in the box below. Your answer might include the number of people ill, the location of the outbreak, or the food product that was implicated.

- ○ Yes
- ○ No

Question 7

Do you own a food thermometer? If yes, please indicate in the box below the type of thermometer that you own (dial instant read, digital, or other)?

- ○ Yes
- ○ No

Question 8

Do you know what temperature needs to be reached to ensure poultry is fully cooked? If yes, please indicate the recommended temperature (°F) in the box below.

- ○ Yes
- ○ No

_________°F

Question **9**

For the following statements, please select the most appropriate answer.

1 - Never | 2 - Rarely | 3 - Sometimes | 4 - Usually | 5 - Always

	1	2	3	4	5
How often do you use a food thermometer while cooking?	○	○	○	○	○
How often do you use a food thermometer when cooking raw breaded chicken products?	○	○	○	○	○
When preparing food at home, how often do you wash your hands with soap and water before handling food?	○	○	○	○	○
When preparing food at home, how often do you wash the counters with soap and water before you begin preparing food?	○	○	○	○	○
How often do you wash your hands after handling raw food?	○	○	○	○	○
How often do you wash fresh fruits and vegetables before use or consumption?	○	○	○	○	○
How often do you wash knives and utensils and scrub cutting boards between preparation of raw and cooked foods?	○	○	○	○	○

The following questions are about the product you just prepared.

Question **10**

Did you notice a label on the product packaging with suggested heating instructions on how to prepare the product? If yes, please proceed to Question 11. If no, please skip to Question 15.

○ Yes

○ No

Question **11**

Did you read the heating instructions?

○ Yes

○ No

Question **12**

Did the heating instructions on the label influence how you prepared the product? Scale values range from "1" (not at all) to "5" (completely). Please circle one.

1	2	3	4	5

Question **13**

What was the recommended cooking temperature or setting for the appliance you used to prepare the product you just cooked?

Oven (Preheated oven temp)	OR	Microwave (Setting)	OR	Deep Fry (Preheated oil temp)	OR	Pan Fry (Heat)
		Low				Low Med

Question **14**

What was the recommended length of time for cooking the breaded chicken product you just prepared?

Question **15**

When considering the product you just prepared, what is the likelihood you would you do something differently if you were to cook the product again?

- Very Unlikely
- Unlikely
- Undecided
- Likely
- Very Likely

Question **16**

If you answered Very Likely or Likely to the previous question, please describe in the box below how you would alter the cooking parameters.

Question 17

In the past year, do you suspect that you or anyone else in your household has had a foodborne illness?

- Yes
- No

Question 18

Have you purchased the type of breaded chicken product that you prepared here today before? If so, please indicate in the box below how often you would prepare this type of product in a given month.

- Yes
- No

Question 19

Please indicate whether the breaded chicken products that you purchase are typically raw or fully cooked?

- Raw
- Fully cooked
- Don't know

Question 20

Have you had any formal food safety training in the last ten years? If yes, please explain your training in the box below.

Question 21

Are you male or female?

- Male
- Female

Question **22**

What is your age?

Question **23**

What is your race?

- ○ White
- ○ Hispanic
- ○ African American
- ○ Asian-Pacific Islander
- ○ Other

Question **24**

How many hours each week do you spend on food preparation?

- ○ Five hours or less
- ○ Six to ten hours
- ○ Eleven to fifteen hours
- ○ Sixteen to twenty hours
- ○ Twenty or more hours

Bottom of Form

THANK YOU FOR PARTICIPATING!

APPENDIX D: Observational Checklist

DIRECT OBSERVATION CHECKLIST

Observation site:
Product Prepared:
Date of observation:
Type of Participant (PMP, AD, FS):
Length of observation:
Name of observer:

1. Were the counters cleaned prior to beginning product preparation?
Comments:
2. Did the individual wash their hands before/after/during product preparation?
Comments:
3. Was the label read prior to beginning the experiment?
Comments:
4. Did the package containing the raw product come in contact with the work area surface at any time?
Comments:
5. If so, did the participant immediately wash the counters with hot soapy water?
Comments:
6. Did the participant allow enough time to preheat the chosen appliance?
Comments:
7. What was the preferred cooking method of the participant (oven, toaster oven, microwave, deep fry, pan fry)
Comments:
8. Did the participant set a timer after placing the product in the cooking device?
Comments:
9. Did the participants flip the chicken strips after 12 minutes of cooking?
Comments:
10. Was a food thermometer used to determine the internal temperature of the product?
Comments:
11. Was a single temperature reading taken? In no, record the number of readings taken.
Comments:
12. If no thermometer was used, how did the individual determine the product was fully cooked?
Comments:
13. Did the individual appear sick?
Comments:
14. After washing their hands did the individual touch any unclean surfaces?
Comments:
15. Did the individual use the same towel to dry their hands as they did to clean up any spills?
Comments:
16. Did the individual wash any used utensils with hot soapy water?
Comments:
17. Did the individual clean the food thermometer after use?
Comments:

****PLEASE NOT ANY BEHAVIORS NOT ON THE CHECKLIST THAT YOU OBSERVE WHILE PARTICIPANT IS PREPARING THE FOOD PRODUCT.**
**PLEASE SEE CODE BOOK FOR SPECIFIC DEFINITION OF EACH SUBJECTIVE BEHAVIOR.

APPENDIX E: Codebook

Meal Preparation Sessions: An Observational Study
Code Book

Behaviors:

Counter Cleaning:

Did the individual clean the counters prior to beginning product preparation?
1 – Correct as defined as an individual used soapy water or another cleaning agent to thoroughly clean the counter top. (Anderson et al. 2004).
0 – Incorrect as defined by the individual did not use soapy water or another cleaning agent to thoroughly clean the countertop.

Did the individual clean the counters after the product packaging came in contact with the counter?
1 – Correct as defined as an individual used soapy water or another cleaning agent to thoroughly clean the counter top (Anderson et al. 2004).
0 – Incorrect as defined by the individual did not using soapy water or another cleaning agent to thoroughly clean the countertop.

Were the other occurrences of potential contamination of the meal preparation environment (ie. Touching raw product and reaching into silverware drawer or touching cabinet handle)?
1 – Yes
0 – No
If this did occur, please note in the comments section what surfaces were touched.

Did the preparer adequately disinfect the surfaces?
1 – Correct as defined as an individual used soapy water or another cleaning agent to thoroughly clean the counter top (Anderson et al. 2004).
0 – Incorrect as defined by the individual did not using soapy water or another cleaning agent to thoroughly clean the countertop.

HANDWASHING:

For all handwashing questions use the following code –

1 – Correct will be defined as hands were placed under running water and soap was at any temperature for any length of time.
0 – Incorrect will be defined as a behavior that should have prompted the individual to wash their hands and did not do so (i.e. touching the raw poultry product and not washing their hands)
In the frequency column please note how many times the individual washed their hands throughout product preparation.
0 – Nothing
1 – Water, soap, < 20 seconds
2 – Water, soap, ≥ 20 seconds
3 – Water, < 20 seconds

4 – Water, ≥ 20 seconds
5 – Hand Sanitizer
6 – Water, soap, ≥ 20 seconds, hand sanitizer after washing.
Labe l/Instructions:

Did the individual read the label instructions?
1 – Yes
0 – No
In addition to noting if they read the label, we are also interested in how long they read the label. Therefore, we will be timing how long the participant read the label. Please record the time in the comments section.

Did the individual read the label once or multiple times?
1 – Single
2 – Multiple
In the frequency column please record how many times the individual read the label.
For instance, did they take the bag out of the freezer, read the label, begin preparation using some method, and then go back to double check the instructions.

Did the individual use an appliance listed on the instructions?
1 – Yes
0 – No

Did the individual follow the label instructions?
1 – Yes
0 – No

KIEV (Microwave)
Did the individual use the microwave to prepare the Kievs?
1 – Yes
0 – No

Was the product cooked from a frozen state?
1 – Yes
0 – No
Definition of frozen: Product was placed in cooking appliance less than five minutes after removing from freezer.
If no, please record in the comments section how long the product remained at room temperature before being placed in the appliance of choice.

Did the participant remove the product from the packaging?
1 – Yes
0 – No

Did the participant use a microwave safe covering?
1 – Yes
0 – No
In the comment column please note if the participant used a **plastic microwave cover** or **paper towel**.

How many pieces were prepared at one time?
1 – One piece
2 – Two pieces
3 – Three pieces

Was the product turned over after 2 minutes of cooking?
1 – Yes
0 – No

Was the product cooked for an additional 2 minutes after turning?
1 – Yes
0 – No

If cooked individually were the Kievs reheated prior to being served?
1 – Yes
0 – No

KIEV (Oven)

Did the individual use the oven to prepare Kievs?
1 – Yes
0 – No
Was the product cooked from a frozen state?
1 – Yes
0 – No

Did the individual allow enough time to preheat the oven to 400F?
1 – Yes
0 – No
Prior to beginning the coding, we will go to Justin Hall and time how long it takes each of the ovens to heat up.
Casey's kitchen took ~ 18 minutes (17:50)
Sarah N's kitchen took ~

Did the individual use a shallow pan for cooking?
1 – Cookie sheet
2 – Glass baking dish
3 – Metal baking pan

Did the individual increase the cooking time for more than two Kievs?
1 – Yes
0 – No

Did the individual set a timer after placing Kievs in oven?
1 – Yes
0 – No

Did the individual open the oven door while the Kiev was cooking?
1 – Yes
0 – No
In frequency column please note how many times the individual opened the door during the cooking of the product.

Chicken Strips (Deep Fry)
Did the individual deep fry the chicken strips?
1 – Yes
0 – No

Was the product cooked from a frozen state?
1 – Yes
0 – No

Was the oil preheated to 350F?
1 – Yes
0 – No
This one will be difficult. Please look to see if the individual tested the oil with water or a small piece of product.

Did the individual cook the filets for the suggested amount of time?
1 – Yes
0 – No

Chicken Strips (Pan Fry)
Did the individual pan fry the chicken strips?
1 – Yes
0 – No

Was the product cooked from a frozen state?
1 – Yes
0 – No

Was the oil preheated?
1 – Yes
0 – No
This one will be difficult. Please look to see if the individual tested the oil with water or a small piece of product.

Did the individual flip the filets halfway through cooking time?
1 – Yes
0 – No

Chicken Strips (Oven)
Did the individual use the oven to prepare the chicken strips?
1 – Yes
0 – No

Was the product cooked from a frozen state?
1 – Yes
0 – No

Did the individual preheat the oven to 450F?
1 – Yes
0 – No

Did the individual use a cookie sheet for cooking the filets?
1 – Yes
0 – No

Did the individual turn the filets halfway through cooking?
1 – Yes
0 – No

Did the individual open the oven door while strips were cooking?
1 – Yes
0 – No
In frequency column please note how many times the individual opened the door during the cooking of the product.

Chicken Strips (Microwave)
Did the individual use the microwave to prepare the chicken strips?
1 – Yes
0 – No

Was the product cooked from a frozen state?
1 – Yes
0 – No
Definition of frozen: Product was placed in cooking appliance less than five minutes after removing from freezer.
If no, please record in the comments section how long the product remained at room temperature before being placed in the appliance of choice.

Were the filets cooked uncovered in the microwave?
1 – Yes
0 – No

How many pieces were prepared at one time?
1 – One piece
0 – Two pieces
3 – Three pieces
4 – Four or more pieces

Did the individual flip the filets halfway through cooking time?
1 – Yes
0 – No

Did the individual let the filets stand for 2 to 3 minutes before serving?
1 – Yes
0 – No

Did the individual switch cooking appliances during product preparation?
1 – Yes
0 – No
Please mark in the comments column which appliances were used. (Ex. Oven to microwave)

Food Thermometers:
Was the individual aware of the food thermometers in the kitchen?
1 – Yes
0 – No

Did the individual use a food thermometer to determine the final internal temperature?
1 – Yes
0 – No

Did the individual use the digital or dial instant read?
1 – Digital
2 – Dial instant read

Did the individual take the temperature of more than one filet or Kiev?
1 – Yes
0 – No
In the frequency column please note how many were temped.

Was a single or multiple temperature reading (s) taken within a single filet or Kiev?
1 – Single
2 – Multiple
If multiple readings were taken please note in the comments column how many readings were taken. Numbers could range from 2 – 10.

Did the individual clean thermometer after use?
1 – Correct, rinsing the thermometer was washed with soapy water and dried with a towel (McCurdy et al. 2006).
0 – Incorrect, no cleaning action or only wiping off the food thermometer with a towel.

Cross Contamination:
For all questions in this category please use the following coding scheme:
1 – Yes
0 – No

Salad Preparation:
Did the individual wash the lettuce prior to serving?
1 – Yes
0 – No

Did the individual wash their hands prior to making the salad?
1 – Yes
0 – No

Did the individual use their bare hands to handle the lettuce and vegetables?
1 – Yes
0 – No
If the individual used a utensil please note in the comments section what the individual used.

Did the individual touch uncooked or partially cooked poultry products without re-washing hands or utensils while preparing the salad?
1 – Yes
0 – No

Final Product:
How did the individual determine if the product was fully cooked?
1 – Cut with a knife
2 – Poked with a utensil
3 – External appearance of product
4 – Time

After initially determining doneness of final product, did the preparer apply additional cooking steps to the product?
1 – Yes
0 – No
ie. return to oven for longer period, put into microwave