Research Project 06-411: Executive Summary

Project Title: Beyond Intent: Assessment and Validation of On-package Handling and Cooking Instructions for Uncooked, Breaded Meat and Poultry Products to Promote Consumer Practices that Reduce Foodborne Illness Risks

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Overall Project Objectives:

- Gather a representative compilation of consumer handling and cooking recommendations as found on packages of heat-treated but not fully cooked or shelf stable poultry products available in retail and food service in the U.S., specifically targeting raw, breaded, boneless poultry products that also may be stuffed or filled, char-marked, or artificially colored. These types of products have been implicated in a number of foodborne illness outbreaks.
- Conduct qualitative and quantitative research with consumers to determine how various food safety handling statements in product labeling are interpreted, including individual intent to act upon such interpretations. Questionnaires and videotaped observations of product preparation were used to identify gaps between intention and execution of food safety steps throughout the preparation process.
- Determine efficacy of current labeling guidelines in producing a safe end product when prepared as instructed under varied conditions, using *Salmonella* spp.-inoculated products in controlled cooking experiments.

Overall Project Conclusions:

1) Foodborne illness outbreaks associated with these products continue to emphasize the risk factors linked to frozen, raw, breaded and/or stuffed chicken entrees. Many consumers remain under the impression that these products are fully cooked at the time of purchase and need only to be reheated. Fully cooked, pre-browned and uncooked products are frequently placed in close proximity in retail frozen foods displays, as well as very similarly packaged in many cases. Most recently, we found these products in single-serving cellophane wrappings, costing less than $1.00 each, and placed directly next to fully cooked products. When fully cooked and raw, pre-browned versions of the same products are available the raw, pre-browned product is generally less expensive, and thus more appealing to budget-conscious consumers.

2) Consumers continue to use preparation methods not specifically suggested by processors of these products, suggesting that statements discouraging product preparation in a microwave oven and promoting food thermometer use are not widely effective as currently being delivered on packages. Even the small percentage of

consumers who attempted to follow safe handling guidelines failed to do so correctly in our consumer study. While an admirable and proactive step by industry leaders, removing microwave instructions from preparation recommendations has not prevented illnesses from being linked to this product category. A contributing factor to this is likely a consumer preference and tradition of utilizing a microwave oven to prepare these convenience oriented products. Further, we found that adolescents (a likely user of these products) were more likely to make critical preparation and cross-contamination mistakes in the kitchen.

3) Cooking studies using microwave ovens commonly found in retail (600 and 1,000 W) revealed that uniform heating is not achieved in this product category regardless of additional treatments such as flipping or covering products during cooking. Heating frozen single or multiple (two Kievs/cordon bleus and three chicken strips) units at one time in the microwave did not significantly impact heating uniformity or final product temperatures achieved. Microwave ovens of wattages below 1,000 W are readily available and reasonably priced for the average consumer based on our casual observations in local retail outlets and the internet. Our thermal profiling data clearly reveals that preparation in lower wattage ovens significantly increases the potential for an undercooked product that may lead to illness. In fact, in inoculated trials, *Salmonella* spp. was consistently recovered from all products prepared using the 600 W microwave oven when analyzed directly after cooking.

Industry Impact:

The meat industry has suffered substantial losses in recent years to do outbreaks of salmonellosis, including financial loss, brand name degradation, and loss of consumer trust. These outbreaks are not confined to commodity based raw meat and poultry; numerous outbreaks and recalls have been attributed to more highly processed multi-component products that contain raw or partially cooked components, including chicken Kievs and frozen potpies. It is becoming more evident that raw ingredients commonly used in these meat-containing processed foods (i.e. flour, vegetables, spices) contribute to the inherent pathogen risks of the products. General marketing oversights and assumptions at processor and retail levels, a multi-industry inability to effectively develop food products and microwaving technologies that are matched and more fail-safe for diverse consumer populations and food products, and ineffective and/or non-compelling consumer safety messages on packages are definitive contributing factors.

The data generated through this research will be of significant benefit to the meat and poultry industry by providing quantifiable insight into the levels of risk involved with these popular product types and will contribute to more effective risk management approaches that processors and trade organizations can utilize to prevent future negative scenarios. This AMI-sponsored project was novel in the sense that it directly combined human observational data with controlled laboratory product preparation studies; results generated a more accurate and inclusive understanding of numerous consumer/product risk issues. Contrary to assumptions of some industry leaders (as expressed during symposia on the topic at the 2009 International Association

for Food Protection annual conference in Grapevine, TX), low wattage microwaves (600 W-750 W) are widely available in retail outlets and through the internet and will continue to present an increased consumer risk, regardless of producers' most recent efforts to modify label instructions. This study strongly suggests that we must establish more effective mechanisms to convey less confusing, more standardized, and more compelling safe handling messages to a diverse consumer population if we are going to protect our product brands. Several critical topics were clearly established during this project that must be addressed through further research to comprehensively manage associated risks in this large product category. Differences in thermal properties of individual constituents (i.e. ham, chicken, cheese, and vegetables) in multi-component frozen products (i.e. chicken cordon bleus) must be better understood, particularly when microwaving is specified, provided as an option, or merely expected. This will better define what preparation schedules and handling information need to be included on different types of products. We must also more clearly understand the differences in microwave ovens across consumers' kitchens and how location-specific factors (loss in power level due to loaded kitchen circuits) impact upon industry-validated safe product preparation instructions. This project provides definitive evidence that observational studies, as opposed to self-reported surveys, are necessary to evaluate the actual effectiveness of consumer messages to influence their "intent" to act upon those statements. Messages should be evaluated in this manner prior to their implementation.

Research Project 06-411: Technical Abstract

Objective 1: Create a representative inventory of consumer handling and cooking recommendations on packages of heat treated not fully cooked, not shelf stable poultry products available at retail and for food service in the U.S. Specifically uncooked, breaded, boneless poultry products that may also be stuff or filled, char-marked, or otherwise artificially colored will be studied.

Methodology:

USDA was contacted in October 2006 and the investigators were informed that approximately 3,000 such products exist in the U.S. marketplace, a limited number of which are within the researchers' region (greater Manhattan, KS and greater Kansas City, KS) of accessibility. Thus, the database was continually updated as contact was made with processors and new products introduced. Fifteen different nationwide chain grocery stores in northeast Kansas were surveyed for frozen, uncooked, pre-browned chicken entrees during June 2006 to April 2009.

Results & Conclusions:

At the commencement of the study, 30 products were found to be available. However, in light of ongoing outbreaks, some processors have stopped production of certain raw products in this category. Three years after the 2005-2006 outbreak in Minnesota, a total of 18 products were found available to consumers. The majority of uncooked, breaded poultry products available were frozen, pre-browned, single-serving, stuffed chicken entrees.

Objective 2: Undertake qualitative and quantitative research with consumers to determine how various safe food handling statements are understood (or misunderstood), and the intention to act upon such understanding. Observation of product preparation by consumers and food service employees and questionnaires will be used to identify gaps between intention and actual behavior.

Methodology:

Forty-one consumers (21 primary meal preparers and 20 adolescents) were recruited from a convenience sample of average consumers in the Manhattan, KS area to prepare a frozen raw breaded boneless poultry product (chicken tenders or chicken Kievs) that was randomly assigned to each participant. Each participant concurrently prepared a side salad to simulate the preparation of a full meal in a model home. A large data set of video-recorded observations was developed and scored by expert analysts to verify actual food safety behaviors (or lack thereof) and was compared to data collected in self-reported participant surveys administered immediately after completing meal preparation activities.

Results & Conclusions:

Numerous distressing food safety behaviors were recorded including inadequate cleaning of kitchen surfaces after exposure to raw products, infrequent and inadequate hand washing,

repeated cross-contamination scenarios, insufficient cooking times and temperatures, failure to abide by label instructions for cooking, and almost complete lack of food thermometer use. Only 4 of the 41 participants (<10%) were observed using a food thermometer to verify the internal temperature of the product. In two of those four instances, the consumer failed to remove the protective plastic sheath from the thermometer probe prior to insertion into the product.

Thirty-seven participants (90%) indicated noticing a label on the product packaging with preparation instructions. Of those, two acknowledged in the self-reported survey that they did not read the instructions. Approximately 61% of participants claimed that the label influenced how they prepared the product, meaning that 39% felt that the label did not influence their handling practices. These results demonstrate a distinct gap between consumer perception of how they follow label instructions (self-reported survey) and the reality of actually using safe preparation practices (observational study). Our study indicated that adolescents made more frequent food safety mistakes when handling frozen raw breaded poultry products compared to their adult counterparts; however, the primary meal preparers also made numerous food safety mistakes.

Consumer awareness of foodborne illness associated with these products was very low. When asked about the likelihood of food poisoning from eating poultry, 44% of participants thought it was "likely or very likely". Most participants (93%) indicated hearing of *Salmonella* causing foodborne illness; however, when questioned as to their knowledge of recent occurrences of the illness due to raw breaded chicken products, only one person responded that they had heard of such an event.

Objective 3: Determine whether current labeling guidelines are effective in producing a safe end product if followed correctly under different preparation conditions using *Salmonella*-inoculated controlled cooking experiments.

Methodology:

This objective was completed in two separate experimental phases, both designed and intended to evaluate the ability and consistency of available product label instructions to provide a safely prepared product for consumption. Three popular frozen raw breaded poultry products were chosen for evaluation for this objective: chicken cordon bleus, chicken Kievs and chicken tenderloins. The ***Phase I Cooking Study*** focused on comparing the effects of microwave wattage (600 W vs. 1,000 W with turntables) and cooking treatment (flipping at mid-point of cooking time, using a microwavable safe plastic cover, and cooking single vs. multiple products) for each product selected. After cooking single and multiple product units for 4 or 7 minutes, respectively, four thermocouples were inserted at defined locations within the product (Figure 1) within 5 seconds of completion of heating and temperature readings were made at each location every half second for two minutes.

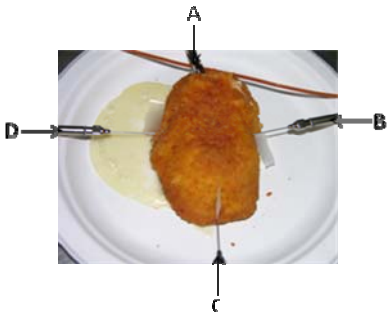

Figure 1: Placement of thermocouples. Temperature determined A) within the center filling of the product, B) and D) ¼" into the chicken on sides, and C) ½" into the chicken at end. All channels monitored temperatures for two minutes at half-second intervals following microwave cooking.

The ***Phase II Inoculated Study*** mirrored the methodology of Phase I; however, this study was performed using *Salmonella* spp.-inoculated products. Each product was inoculated with 0.025 ml a 5-serovar cocktail at each of ten pre-defined locations using hypodermic tuberculin needles, totaling 0.25ml of inoculum per product to achieve a *Salmonella* spp. level of approximately 6 log cfu/g. Based on observations in Phase I of heating occurring at each of the four thermocouple locations, and evidence of undercooked chicken in the top portion of the products, a fifth thermocouple in this location was added during Phase II to measure temperature trends for products cooked in single servings. However, due to the limited channel capacity of the data logging system used for this study, we were unable to incorporate this additional channel measurement into the products cooked as multiple servings.

Results & Conclusions:

Phase I data clearly demonstrated that three of the five cooking variables evaluated resulted in p-values reflecting significance within a 95% confidence level ($p<0.05$). Product type evaluated ($p=0.0009$), microwave oven wattage ($p<0.0001$) and thermocouple location in the product ($p=0.0184$) had significant effects on the end temperature achieved of all products. Overall, products prepared in the 600 W oven were consistently undercooked and did not reach 165°F in at least one location of measurement. Final product temperatures as low as 93°F were observed. Preparation in single versus multiple product units, nor cooking treatment (flipping or covering), had a significant effect on the end temperature of the products using the parameters considered in this experimental segment.

Phase II was comparable to Phase I in both methodology and statistical results. Consistent with cooking variables that affected end-point product temperature variability, *Salmonella* spp. was consistently recovered from products prepared using the 600W microwave oven. Using Schaffe's test to conservatively evaluate the temperature data, products prepared as single or multiple servings in 600 W ovens consistently showed no significant differences when compared to the uncooked, inoculated control products. Likewise, *Salmonella* spp. was recovered at high level and frequency from these cooked products. Salmonella reductions were highly variable ranging from 1-6 log cycles. The same products prepared in 1000W ovens did not appear to be a food safety risk, as all temperatures recorded were ≥165°F. No viable *Salmonella* spp. were detected when a 1,000 W oven was used and products were either flipped or covered during heating. Very low survival was detected using sample enrichment only when covering or flipping was omitted.

The heating instructions for most raw stuffed, breaded chicken entrees that we observed were validated by processors based upon a 1,000 W microwave oven. Similar partially or fully cooked product preparation instructions currently available also tend to use the 1,000 W standard. While most consumers own a microwave oven, it is risky for processors to presume that most consumers have a 1,000 W microwave oven and will be preparing the product in a microwave of equal or greater wattage. Some package statements, particularly more recent ones, provide different heating times/instructions for microwaves of different wattage ranges. Although a significant positive approach by industry, our informal surveys indicate that a large percentage of consumers do not know and do not seem interested enough to check the wattage of their personal microwave oven. The current study did not evaluate microwave ovens having wattages between 600 and 1,000 W. It is speculated that a significant level of risk also might be

encountered for raw breaded products cooked in these ovens. A confounding factor is that home microwaves may not be performing at the rated wattage due to age of oven and/or overloaded kitchen electrical circuits.

Research Project 06-411: Final Report

Project Title: Beyond Intent: Assessment and Validation of On-package Handling and Cooking Instructions for Uncooked, Breaded Meat and Poultry Products to Promote Consumer Practices that Reduce Foodborne Illness Risks

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Report Date: 1 November 2009

Background:

Salmonellosis is the most common reported foodborne illness in the United States. Annually, approximately1.4 million cases of salmonellosis occur; however, only about two percent of cases are reported to the Centers for Disease Control (Centers for Disease Control and Prevention, 2006 #231). Poultry is one of the most common food products linked to cases of salmonellosis. Frozen, microwavable pre-browned chicken entrees are now recognized as a vehicle for *Salmonella* outbreaks. In the last decade, eight outbreaks worldwide have been attributed to pre-browned, stuffed, breaded chicken entrees, as well as chicken nuggets and tenderloins. In all outbreaks, consumers considered the products fully cooked, prepared the products in a microwave, and did not measure the internal temperature of the product prior to consumption—each element serving as a potential contributing factor to contracting a foodborne illness (Kenny, 1999 #84; MacDougall, 2004 #85; Medus, 2006 #91; Medus, 2006 #97; Smith, 1999 #92). Foodborne illness outbreaks and product recalls associated with not-ready-to-eat (NRTE) products have forced considerable regulatory and industry attention onto these products.

Over the last decade, approximately 150 individuals have been identified as falling ill after consuming undercooked pre-browned chicken entrees. The largest outbreak affecting 33 individuals occurred in Minnesota in 1998. The outbreak investigation by the Minnesota Department of Health identified consumer confusion regarding the raw nature of the product and a primary contributing factor. Sickened individuals believed that the products were fully cooked, only needed to be reheated, and prepared the product in a microwave oven. In light of the outbreak, the company manufacturing the implicated product made several changes to the product label. The words "not pre-cooked" replaced "ready to cook" on the principle display panel (PDP). 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, manufacturers lengthened the cooking times for both the conventional oven and the microwave portion of combination cooking (i.e. conventional oven and microwave). However, even though illnesses were linked to individuals who cooked the product in the microwave, no changes were made to the microwave instructions (Smith, 1999 #92; Smith, 2008 #332). Despite the public health interventions attempted in 1998, six additional outbreaks associated with raw, frozen breaded stuffed chicken entrees (Table 1) have been identified to date.

Table 1: Outbreaks associated with raw, frozen pre-browned chicken entrees

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
2008	Minnesota	4	*S.* Enteritidis	Stuffed Chicken Breast
2008	Minnesota 11 other states	14 18	*Salmonella* I4,12:i	Stuffed Chicken Breast

From August 2005 to February 2006, 27 more cases of salmonellosis were associated with raw, frozen breaded stuffed chicken entrees. As a result, the processor of the implicated chicken entrée voluntary recalled approximately 75,800 pounds of product. Illnesses from the previous outbreaks prompted the United States Department of Agriculture – Food Safety and Inspection Service (USDA-FSIS) to consider what actions the agency should take to prevent further illnesses associated with frozen NRTE products. In March 2006, FSIS sent a letter to all processors of uncooked poultry products encouraging the industry to make sure their product labels are adequate enough to inform the public of the safe manner in which the products should be handled to ensure a safe end product (Post, 2006 #102). In addition, the National Advisory Committee for the Microbiological Criteria for Foods (NACMCF) was charged with developing additional guidelines that detail the safe cooking of NRTE poultry products such as those implicated in the outbreaks. The document recommended the following: using the principlel display of the label to advise consumers that the product is uncooked; informing consumers that microwaving raw poultry from a frozen state is not advisable unless validated instructions are provided to them that reach the recommended end point temperature if prepared correctly; and, reminding consumers to fully cook the product to an internal temperature of 165°F when the product is raw but appears to be fully cooked (National Advisory Committee on the Microbiological Criteria for Foods, 2006 #333).

In April 2006, FSIS issued a labeling policy document to industry regarding the modifications that are necessary for the labeling of uncooked, breaded (both pre-browned and not pre-browned) boneless poultry products. Under the new guidelines, the labels must clearly identify the product category of prepared, but NRTE. 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 effectively relay this information to the consumer (Heller, 2007 #296; FSIS, 2006 #99). Common products found within this category are chicken nuggets, chicken strips, chicken fritters, and stuffed chicken entrees—all products implicated in previous outbreaks. Industry has positively responded by changing their product labels to include the recommended changes set forth by regulatory agencies. Despite the revised labels, 36 illnesses within the last year have been linked to pre-browned poultry products.

The goals of this AMI study were to:

1. Gather a representative compilation of consumer handling and cooking recommendations as found on packages of heat-treated but not fully cooked or shelf stable poultry products available in retail and food service in the U.S., specifically targeting raw, breaded, boneless poultry products that also may be stuffed or filled, char-marked, or artificially colored. These types of products have been implicated in a number of foodborne illness outbreaks.
2. Conduct qualitative and quantitative research with consumers to determine how various food safety handling statements in product labeling are interpreted, including individual intent to act upon such interpretations. Questionnaires and videotaped observations of product preparation were used to identify gaps between intention and execution of food safety steps throughout the preparation process.
3. Determine efficacy of current labeling guidelines in producing a safe end product when prepared as instructed under varied conditions, using *Salmonella* spp.-inoculated products in controlled cooking experiments.

Objective 1:

Objective 1 of the study involved a review and analysis of raw, frozen pre-browned chicken entrees currently available to consumers.

Methodology:

Fifteen different nationwide chain grocery stores in northeast Kansas (Manhattan, KS and greater Kansas City, KS areas) were surveyed for frozen, uncooked, pre-browned chicken entrees between June 2006 and April 2009. Common products found within this category were chicken nuggets, chicken strips or tenderloins, and stuffed chicken entrees—all products implicated in previous illness outbreaks. At the commencement of the study, 30 products from this category were available at retail. However, as a result of continued outbreaks certain processors have switched to offering only fully cooked products. Three years after the 2005-2006 outbreak in Minnesota, a total of 18 products were found available to consumers. The majority of uncooked breaded poultry products available to consumers were frozen, pre-browned, single-serving, stuffed chicken entrees.

Results and Discussion:

The products implicated in the outbreaks fall into the USDA's process category called "heat treated, not fully cooked, not shelf stable". During processing, the product undergoes a partial-frying step to ensure that its shape is maintained and impart a golden brown color to the breading prior to the product being frozen and packaged (Bucher, 2008 #339). The pre-browned nature of the product makes the product appear fully cooked. Despite the cooked appearance of the outside, the poultry within remains raw. When placed side-by-side, without packaging, fully cooked and uncooked products have a similar appearance (Figure 1).

Figure 1: Similar appearance of fully cooked and uncooked breaded products.

The products under review can be found in the frozen food section of most grocery stores. Grocery stores surveyed contained either of two different types of display cases for frozen food. The first, an upright display case, normally contained all poultry products regardless of their cooked or non-cooked status. Here, fully cooked products were placed directly next to raw products (Figure 2). The second, a floor display case, has both fully cooked and uncooked products in the display case. On two separate occasions, products were not separated based on their cooked nature, but were haphazardly thrown into the display case. In a store located in many cities nationwide, on two separate occasions, uncooked stuffed chicken entrees were found buried beneath fully cooked products that at one time had been separated. It is important for grocery stores to maintain a clear and obvious separation of raw and fully cooked products. Improper consumer food handling may be influenced by the placement of raw and cooked products in close proximity in retail display. A hurried consumer, while shopping, could potentially grab a product they believe to be fully cooked, but in fact is raw, and proceed to cook it as if it was a fully cooked product. However, not all stores followed this trend; some have clear separation between raw and fully cooked poultry products.

Figure 2: Raw and fully cooked products in close proximity in a retail display case.

Both fully cooked and uncooked pre-browned chicken entrees are available to consumers. Initial accounts during previous outbreaks suggested that unclear instructions may have led to undercooking of the product by consumers. While processors view the products as completely different, consumers may confuse the products and assume all entrees are fully cooked. The cooking instructions for fully cooked and uncooked chicken entrees are also very similar. For example, one product suggested cooking in a conventional oven for 25 minutes at 350°F for fully cooked chicken breast stuffed with broccoli and cheese and 30 minutes at 400°F for an uncooked stuffed chicken breast with broccoli and cheese.

Frozen, uncooked, pre-browned stuffed chicken entrees are typically found individually packaged in plastic wrapping and boxed. Products, such as chicken nuggets or chicken strips, are normally sold in a bag that can be resealed. Uncooked and cooked products from several manufacturers have similar packaging, with the wording found on the principle display differing between the products. For example, on fully cooked products, a common statement found is "heat and serve" placed on the principle display while on uncooked products, "cook thoroughly" or "ready to cook" can generally be found on the package (Figure 3).

Figure 3: Product packaging for fully cooked versus uncooked chicken products.

The packages of such products have two panels, the principle display and back panel, both which contain important information for the consumer. The principle display of the label is the portion of the package that is most likely to be seen by the consumer at the time of purchase and should bear prominent and clear terms that convey that product contains raw or uncooked poultry. All products found in retail contained a clear message to the consumer stating, "UNCOOKED: For food safety, cook to a minimum internal temperature of 165°F measured by a meat thermometer." The statement is put on the principle display for a reason—to remind the consumer the product is raw and must be fully cooked prior to eating the entrée. Consumers choosing to ignore the statement are putting themselves at risk of contracting a foodborne illness.

The back panel of the package contains the suggested cooking methods for each specific product. The most common method listed on the cooking instructions was the conventional oven, as it provides more uniform cooking compared to other methods of cooking. A key statement listed separate from the cooking instructions on several packages was "ovens vary, cooking time may need adjustment." This statement conveys to the consumers that not all ovens cook at the same rate, thereby, suggesting that even though one follows the listed cooking

instructions it may not result in a fully cooked product. This important statement was not found in bold letters and tended to blend in with the rest of the text found on the product's packaging. Consumers must realize that the only way to ensure the product is fully cooked is to check the product in multiple locations with a food thermometer.

Since the completion of the study, Kroger has switched their packaging of raw, breaded chicken entrees. The products were originally individually packaged in plastic wrap and placed within a cardboard box containing the recommended cooking and handling instructions. Kroger is now packaging their products in individual clear packaging (Figure 4). The products are housed in a cardboard sleeve that holds approximately 30 entrees. The packaging mimics that of other microwavable entrees now more than ever. The product is not shelved with the rest of the raw chicken entrees, but instead across the aisle in a completely separate display case. The instructions have also been slightly altered. In addition, to the cooking instructions, diagrams of an oven, microwave, and thermometer now appear on the instruction panel of the product. The instructions state to cook the product only in a conventional oven. The processor has gone as far as providing a picture with a microwave with a prohibited sign over the image (Figure 4b). The processor is using this creative option to convey to consumers that microwaving the entrees is not an acceptable option.

Figure 4a: Alterations in product packaging. The image on the left displays both the old (left) and new product packaging (right).

Figure 4b: The image on the left shows the addition of pictures to the label to demonstrate proper cooking and thermometer use.

The previous packaging contained a statement to consumers encouraging the use of a meat thermometer to ensure the product has reached its necessary end-point temperature. The statement instructed consumers to check the entrée's end-point temperature in multiple locations.

The new packaging has added a diagram of how to properly insert your thermometer into the thickest portion of the entrée. While typically correct, the thickest portion of this particular type of entrée is already fully cooked—the cheese. Further, results observed in Phase 2 of this study indicate that multi-component products heat in a highly variable manner, especially when microwaved, and the thickest portion of the product is not always the slowest to reach target temperature. By following this approach, consumers may be receiving an inaccurate temperature estimation of the entire product. Consumers should be encouraged to take multiple temperature readings throughout the product rather than taking only the thickest portion. While the changes to the label may be seen as beneficial the product placement in the store should be re-evaluated. All raw chicken entrees should be in the same display case and not commingled with fully cooked entrees.

The microwave oven can be found in 90 percent of homes across America (USDA-FSIS, 2006 #340). The microwave oven offers convenience, but consumers must consider the risks that go along with preparing an entrée in the microwave. Microwavable foods are becoming a growing trend. On average, 94% of shoppers purchase frozen food some of the time, with 30% always buying frozen food (Cates, 2008 #314). Prior to the 2005 – 2006 outbreak, many breaded stuffed chicken entrees were marketed as microwavable. After consumers fell ill from preparing the product in the microwave oven the instructions were re-evaluated. During the revamping of the cooking instructions most processors voluntarily removed microwavable instructions. However, even though microwave instructions were removed, the remaining packaging characteristics were not changed for most products. A repeat purchaser may easily continue to purchase the product, cooking from habit and not realize that microwave instructions have been removed. Additionally, while most eliminated the microwavable instructions, some processors chose for them to remain as a recommended or acceptable cooking method. It is possible that consumers may assume that cooking instructions listed for one particular microwavable stuffed chicken entrée can be applied to all stuffed chicken entrees, even those not intended for the microwave. Finally, it seems apparent from our studies that certain consumers will choose to microwave these convenience products even though they may be aware that the product package does not state microwaving as an acceptable heating method, and moreover, even when the package clearly states that microwaving is not appropriate.

While most products cooked in the microwave are quick and easy; the instructions for cooking the stuffed chicken entrée in the microwave are very detailed and potentially time consuming. When cooking a stuffed chicken entrée in the microwave a consumer cannot punch in the cooking time and walk away. The consumer is instructed to place the stuffed entrée upside down on a microwave safe plate and cook on HIGH for 2 minutes; turn 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, consumers may choose to enter in a single cooking time of five minutes. Consumers may not understand that cooking the product for five minutes non-stop without flipping does not achieve the same effect on the product as following the recommended cooking instructions. Microwaves also heat unevenly, and can leave cold spots in the food that could harbor dangerous pathogens. In flipping the product during cooking the product receives a more uniform exposure to heat. In the case of stuffed Kiev and cordon bleu products, flipping the product causes the melted internal components to migrate to the opposite side of the product, thus, better distributing the hot temperature.

The USDA advises consumers against cooking raw poultry in the microwave, but still allows processors to put microwavable instructions on the product label (USDA, 2008 #341). Microwave instructions, if present on the label, must have been validated by the processor. Processors do not validate their instructions based on all wattages of microwaves available to consumers. Instead, most validate using an 800 watt microwave (Meyer, 2008 #342). A wide range of microwaves are on the market today, with wattages ranging from 600 to over 1200. As wattage increases so does the price of the unit in most cases. The lower wattage microwaves are the cheapest and may be more appealing to consumers during hard economic times. Additionally, marketing of the lower wattage microwaves tends to peak in August—when kids are heading off to college. The lower wattage microwaves are the perfect fit for any dorm room or apartment. Further, elderly consumers (especially those living alone) may be enticed to purchase these smaller microwaves to suit their needs for heating single serving entrées. When validating cooking instructions, processors should take into account all wattages of microwaves. Consumers may not understand that the microwaves lose efficiency over time. So even if they are following the cooking instructions, an increase in cooking time may be needed to ensure a safe end product. Again, this would only be determined if consumers were properly using a food thermometer.

Two years after label changes took place, only two products from this general category were available to consumers in the stores surveyed that contained microwavable instructions. Most products surveyed contain a statement advising consumer against using a microwave oven (i.e. DO NOT MICROWAVE or not intended for the microwave oven). However, while bolded, the statement often does not stand out amongst other label instructions.

Frozen, uncooked, pre-browned chicken entrees are often packaged individually and boxed. As discussed above, with boxed entrees the back panel contains the cooking instructions. In some situations, breaded poultry products are sold in bulk. A case-control study completed in Canada reported that one quarter (82) of participants repackaged large boxes of the product into smaller freezer portions some of the time. Furthermore, 32 percent did not retain the cooking instructions from the box. In doing so, consumers are relying on memory regarding how to properly prepare the entrée. On the other hand, consumers may be cooking the products as they see fit. For example, in the 1998 outbreak in Australia involving chicken nuggets, a mother of one of the affected children thought the product was fully cooked and her usual practice was to heat six nuggets in the microwave for two minutes (Kenny, 1999 #84). The product the mother had prepared did not have microwavable instructions.

Conclusions:

The continued outbreaks associated with these products continue to highlight the risk factors linked to frozen, uncooked stuffed chicken entrees. Many consumers are still under the impression that these products are fully cooked and need only be reheated. Fully cooked and uncooked products are being placed in close proximity in retail and being packaged in similar manners. Individuals often use cooking methods not suggested by the processor. Actions taken by consumers suggest that statements discouraging cooking of the product in a microwave oven and promoting food thermometer use are not effective and are being widely ignored. Removing microwaving instructions from the cooking recommendations has not prevented illness from being linked to these products.

Processors of raw, frozen stuffed chicken entrées should offer only a fully cooked choice for retail sales. However, health officials reported after meeting with processors of raw, frozen

stuffed chicken entrées that pre-cooking the product was not an option. The processors explained that for an unknown reason the pre-cooked product does not sell as well as the raw product (Weise, 2008 #334). If processors are not willing to pre-cook the entrée, other means of ensuring the overall safety of the product should be pursued. Label changes have been revised. Kroger is the first company to provide diagrams for consumers to follow in addition to cooking instructions. The diagrams may be a very effective way of communicating to individuals who do not speak fluent English, or may be more influential for adolescents and possibly elderly consumers. This should be evaluated further in observational studies similar to the ones used in Phase 2 of this study. However, until consumers start following validated label instructions, and additional risk management steps are taken by the industry, illnesses will likely continue to be linked to raw, frozen stuffed chicken entrées.

Objective 2:

Objective 2 of our study focused on evaluation of two consumer groups (primary meal preparers and adolescents) to quantify specified food safety behaviors when handling frozen raw breaded poultry products while preparing a simulated meal in a model home kitchen (observational methods). Subsequently, a self-reported written survey was administered to contrast "consumer intent" with actual practices in the kitchen.

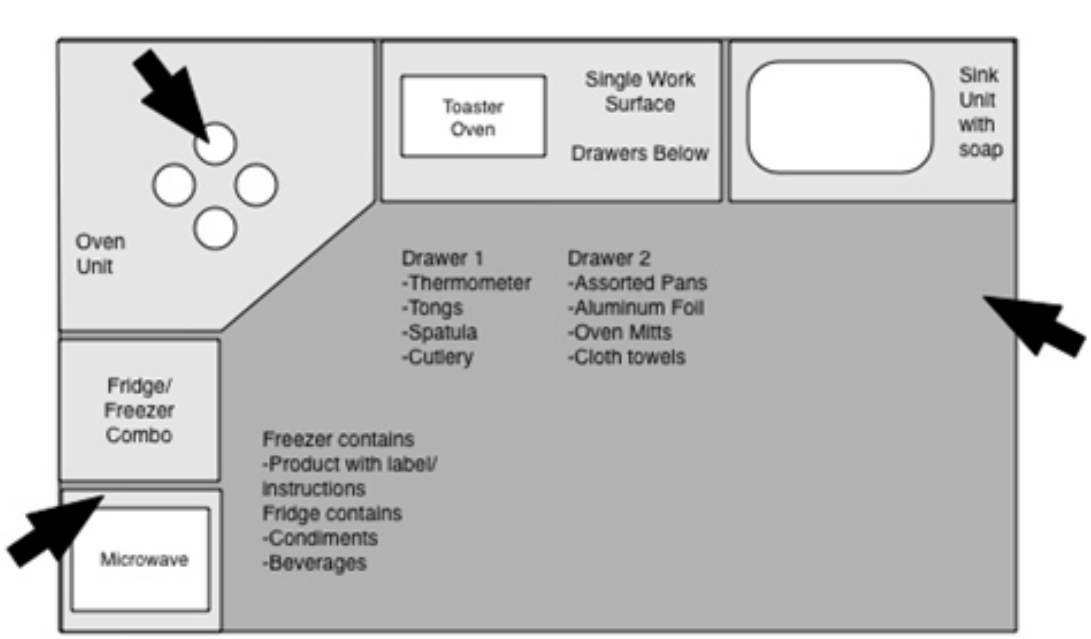
Methodology:

Participants were video-recorded while preparing a meal with 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 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 one 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.

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 from the community at large using advertisements (internet listings and flyers in local media) were abandoned due to a low response rate. In order to minimize the amount of reactivity involved with direct observational activities, the study was advertised as a food quality study rather than a food safety study. A total of 41 individuals participated in the study; 21 primary meal preparers (3 males/18 females) and 20 adolescents (10 males/10 females). For this study, primary meal preparers were defined as those who prepare food in the home at least twice a week (Clayton *et al.*, 2003). Adolescents were defined as children 12 to 14 years of age (Centers for Disease Control and Prevention, 2005). This study was approved by the Kansas State University Institutional Review Board. All study participants signed informed consent forms prior to participating. Each participant received $25 USD and a food safety themed t-shirt for their participation.

All food preparation observations were conducted in one of two model home 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. A camera viewing the stove, one viewing the sink, and another viewing the length of the countertop, recorded each participant's movements. A schematic of the model kitchens is provided in Fig. 5 (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 ingredients for a side 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. Prior to the arrival of each participant, the randomly assigned chicken entrée was placed in the kitchen's freezer in the original packaging provided by the manufacturer. A copy of each product's label instructions can be found in Table 2. Additionally, three plastic bowls containing the pre-cut 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 common 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 and the script of instructions to participants, and to ascertain any significant differences resulting from kitchen layouts prior to the observation of the 41 participants.



* Arrows denote camera placement and viewing direction

Figure 5. Schematic diagram of model kitchens used to conduct observational studies on consumer handling of frozen, raw, breaded poultry products.

Table 2. Cooking instructions present on frozen, raw, breaded poultry entrees use in consumer observational studies.

Chicken Kievs and Chicken Cordon Bleus
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 portions' 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 Tenderloins
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.

At the start of each session, a trained researcher provided a brief overview of the kitchen and its contents to each participant. Each participant was invited to spend time (approximately five minutes) familiarizing themselves with the kitchen. During the introduction, participants were asked to prepare a meal for three people using the assigned frozen entrée and salad mix as they would in their own home. Reading materials and snacks were made available in an adjacent commons area 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 simultaneously completing the food study.

Questions for the survey were adapted from previous food safety-based studies (Anderson *et al.*, 2004, Haapala and Probart, 2004, Jay *et al.*, 1999, Kendall *et al.*, 2004, McCurdy *et al.*, 2006, Woodburn and Raab, 1997). The survey consisting of 24 questions was given after completion of each food preparation session, not before, to not influence participants' thoughts regarding microbial food safety before their meal preparation session. The main objectives of the survey were to evaluate participants' awareness of foodborne illness; frequency of purchasing, preparing, and consuming uncooked, breaded chicken products in the home; ownership and reported frequency of use of food thermometers; and the participants' reported handwashing behaviors. The questionnaire was pre-tested and 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.

When all observations were completed (n=41), two research assistants translated observed participant behaviors from the video-recordings into code using a detailed observational checklist based upon the U.S. Centers for Disease Control and Prevention's identified risk factors for foodborne illness (Bean et al., 1996). The following behaviors were tracked: handwashing, avoiding cross-contamination, determining doneness of the chicken product, food thermometer use, and reading and applying product label instructions. Research assistants also coded participants' follow-through with label instructions provided on the product packaging. To establish intercoder 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 literature (Anderson *et al.*, 2004, Jay *et al.*, 1999, Kendall *et al.*, 2004). Each research assistant viewed the remaining videos independently and codes were assigned to the behaviors to create the research data set.

A coding scheme of correct, incorrect, or not performed was used for most behaviors. The remaining behaviors were coded as either "yes" (i.e. observed) or "no" (i.e. not observed). Percent agreement between coders for each behavior was calculated by dividing the number of times agreed upon for the specific behavior by the total number of observations (Babbie, 2006). In circumstances in which an agreement could not be reached, a third research assistant was trained to recode those specific behaviors. The observational and survey data were analyzed for descriptive statistics using the Statistical Package for the Social Sciences (SPSS Inc, Version 15, Chicago, IL).

Results and Discussion:

The mean ages for primary meal preparers and adolescents participating in this study were 40.3 ± 8.9 (range 25 to 55) years and 12.9 ± 0.6 (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.

Table 3 outlines a total of six instances in which handwashing would be considered advisable to prevent foodborne illness during the meal preparation observed in this study. Ninety percent of primary meal preparers reported in post-preparation surveys that they washed their hands both prior to beginning food preparation and after every occasion where they handled raw poultry. During video observation, most primary meal preparers (90.5 percent) washed their hands correctly prior to beginning product preparation, but almost half (47.6 percent) failed to wash their hands correctly after handling the raw poultry products. 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 self-reported handwashing behaviors, only slightly more than 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 products (Table 3). 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 re-entering the room in which the meal was being prepared after leaving.

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 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 both directly and indirectly ranged from 2.8 to 4.6 times for all participants.

Nearly half (42.5 percent) of participants reported on their self-surveys as knowing the suggested end-point temperature for cooking poultry to ensure doneness. When asked the final recommended internal temperature for chicken, the mean response was 214°F with a range of

responses from 140°F to 450°F. A variety of ways in which participants determined if the product was fully cooked are outlined in Table 5.

Table 3. Observed instances of handwashing among primary meal preparers and adolescents.

Primary Meal Preparers (n=21)				
Behavior	No. Correct (%)	No. Incorrect (%)	Not Applicable	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 (%)	Not Applicable	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)	--

* Average length of time spent handwashing was only figured for those that performed handwashing correctly

Table 4. Instances of cross-contamination during meal preparation.

Primary Meal Preparers (n=21)				
Behavior	Yes (%)	No (%)	Not Applicable (%)	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 (%)	Not Applicable (%)	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)	--	--

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)

Table 5. Methods observed to determine final product doneness by study participants.

For both primary meal preparers and adolescents, no attempt was made to determine product doneness by the majority of participants (46.7 and 65.0 percent, respectively; Table 5). Most often, following the expiration of the 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 external 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.

Though both labels instructed consumers to ensure that the internal temperature of the product reached 165°F as measured by a food thermometer, only five participants attempted to use a food thermometer to determine the doneness of either chicken entrée (Table 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. In the survey, only 19.5 percent of participants reported using a food thermometer to determine the internal temperature of raw breaded chicken products. 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 plastic sheath on the digital thermometer probe prior to taking the internal temperature reading, and therefore used the instrument incorrectly.

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 7 outlines the behaviors observed for reading label instructions. Both the chicken Kiev and 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,

Table 6. Observed food thermometer use by study participants.

Primary Meal Preparers (n=21)			
Behavior	Correct (%)	Incorrect (%)	Not Applicable
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 (%)	Not Applicable
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)

* Four participants using a food thermometer to measure internal temperature all took a single reading

* 50% of primary meal preparers used a digital (n=2) and 50 % used a dial instant read (n=2)

* One adolescent used a dial instant read food thermometer to measure internal temperature and took a single reading

only 61 percent 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 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.

Table 7. Observations of particpants' reading and applying product label instructions.

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)	--	--

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 as suggested by the label. One participant used a microwave setting not found in the preparation instructions labeled "Poultry," that was 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 tenderloins or Kievs, and/or opened the door (often numerous times) while the entrées were cooking. Oftentimes, participants who successfully allowed the appliance to preheat did so while the product waiting to be cooked remained at room temperature, such that it was not in a 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 cooking instructions provided on the product labels.

Conclusions:

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. Consistent with previous research, a clear discrepancy was identified between direct observational and self-reported data. When directly comparing the two methods, observational data clearly offers two advantages—it captures actual behavior and an individual's behavior is captured in context (Gittelsohn et al., 1997).

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 tenderloins, yet they 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' low likelihood to wash hands after handling raw product led to increased instances of direct cross-contamination compared to primary meal preparers.

Many participants reported owning a food thermometer (73.2 percent) and using it when cooking raw, breaded chicken entrées (19.5 percent); however, when observed, few participants

measured the final internal temperature, demonstrating again the discrepancy between self-reported and actual behavior. Participants within this study relied on inadequate techniques to estimate when their chicken entrées were cooked to a microbiologically safe end temperature. 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, while the majority of participants either cut into the meat product or used visual cues to determine doneness. 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. Participants in any study utilizing direct observation may alter their behavior due to their awareness of being watched. Participants were told the goal of the study was to evaluate product quality rather than product safety, intending that individuals be less conscientious of their food handling behaviors, as they were blind to the type of behavior being evaluated. A limitation associated with using self-reported surveys is the well-documented 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 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. Outbreaks associated with raw, breaded chicken products such as those used in the present study continue to be reported. The present study provides novel findings that will contribute to the overall understanding of consumer behaviors in response to safe food handling labels for processed meat and poultry products—specifically frozen, uncooked, breaded chicken products.

Objective 3:

In Objective 3 studies, we attempted to determine whether current product cooking instructions appearing on packages are effective in producing a safe end product if followed correctly under different preparation conditions using non-inoculated and *Salmonella*-inoculated controlled cooking experiments. Consumer cooking actions observed in Objective 2 studies, namely use of microwavable covers and flipping products at mid-point of the cooking time, were evaluated to determine their effect on product heating.

Phase I Methodology (Non-Inoculated Temperature Profiling Study):

All products—chicken cordon bleus, chicken Kievs, and chicken tenderloins—were purchased from the local grocery chain and manufactured at the same processing facility. All products were stored at 0°F until the time of the study. When the study was being designed, microwaving instructions were still presented on the product label as an acceptable cooking method for raw, breaded chicken entrees. However, in response to continued outbreaks of

salmonellosis with such entrees, processors have voluntarily chosen (in most cases) to remove microwavable instructions from recommended cooking methods. This in turn forced us to rely on previously available microwaving label instructions (Table 2) to complete our cooking experiments. However, when products were purchased, some boxes still contained the microwave preparation instructions.

Frozen, raw, breaded chicken products were prepared in a 600 W microwave oven (Daewoo, Model No. KOR-6LOB), 1,000 W microwave oven (Kenmore, Model No. 721.66029500), and a conventional oven (Whirlpool, Model No. RF315PXDN0). Treatment parameters were repeated for each product type using the previously identified appliances. All treatments were repeated five times for both the 600 W and 1,000 W microwave ovens. A total of four treatments were applied to the products during cooking. Treatments were developed based on preparation instructions provided on the available product's packages. The treatments included flipping/no covering (F-NC), no flipping/no covering (NF-NC), flipping/covering (F-C), and no flipping/covering (NF-C). All chicken entrees were cooked in each microwave per the processor's previously available cooking instructions, both individually and in multiples (two at a time). Briefly, stuffed chicken entrees, when cooked individually, were cooked for a total of 4 minutes. An additional three minutes of cooking time was added when products were cooked in multiples. The chicken tenderloins were cooked only in multiples (three pieces) for a total time of 7 minutes. Flipping was achieved by turning the product over half-way through the cooking process. When required for specific treatments, entrees were covered during cooking with a plastic microwave-safe covering commonly found in local discount retailers. Immediately (within 5 seconds) following the completion of the cooking period, the products were promptly removed from the cooking device and four hypodermic probes (HYP-2, Omega Engineering, INC. Stamford, CN) were inserted at specified depths and locations (Figure 6). Temperatures were recorded using a USB-TC data-logging system (Measurement Computing Corporation, Norton, MA) for 2 minutes at half-second intervals.

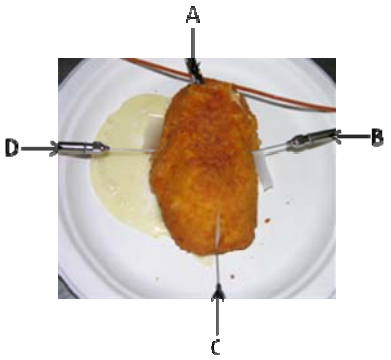


Figure 6: Placement of thermocouples. A) monitored the temperature within the filling of the product. B) and D) probes were inserted ¼" into the sides of the chicken product, and C) probe was inserted ½" into the end of the chicken product. All channels monitored temperatures for two minutes following cooking.

To generate product temperature profiles during cooking in a conventional oven, products were left at 39°F to slightly thaw overnight to facilitate thermocouple placement into the frozen products. Four thermocouples (5SRTC-TT-T-30-72, Omega Engineering, INC. Stamford, CN) were inserted at specified depths within the product and refrozen. Four treatments were applied to the products during cooking. These included metal cooking sheet/continuous cooking (M-C), metal cooking sheet/discontinuous cooking (M-DC), glass cooking pan/continuous cooking (G-C), and glass cooking pan/discontinuous cooking (G-DC). Discontinuous cooking was defined as opening the oven door two times during cooking for a duration of 10 seconds each. Products were then cooked per processor's cooking instructions. Briefly, stuffed chicken products and

chicken tenderloins were cooked at 450°F for 32 minutes and 400°F for 20 minutes, respectively. The chicken entrees were cooked only in multiples with temperatures being recorded for two of the three entrees (i.e. center and one of the outside products) two times every second. Temperatures were recorded using the USB-TC data logging system. All treatments were repeated five times.

Data were analyzed using the General Linear Model in Statistical Analysis Software (SAS Institute Inc., Cary, NC). The model included the main effects of probe location within the product (channel), treatment, wattage, product, and type. Means were separated using the Least-Squares Means procedure of SAS and results were analyzed at the 0.05 level of significance.

Results and Discussion:

The temperatures of all products prepared in the conventional oven were monitored throughout the entirety of the cooking process, as opposed to immediately after completion of the cooking process in microwave ovens, using thermocouples. All entrees, regardless of cooking treatment utilized, reached the recommended end temperature of 165°F in less time than the recommended cooking time on packages (data not shown). When the entire suggested cooking time was used, temperature readings ranged from 170-208°F throughout the products.

The microwaving experimental data were analyzed to determine the effect five variables—product (cordon bleu, Kiev, or tenderloins), wattage (600 W and 1,000 W), treatment (F-C, F-NC, NF-C, NF-NC), type (cooked individually or in multiples), and channel (I, II, III, IV)—had on the overall end temperature (Table 8). Three of the five variables [product ($p=0.0009$), wattage ($p<0.0001$), and channel ($p=0.0184$)] had a significant effect on the end temperature of the entrees. The other two variables, type ($p=0.2979$) and treatment ($p=0.8429$), had little to no effect on the end temperature. Treatment had the largest p-value of 0.8429 suggesting very little variation between types of treatments applied to the products. With a large p-value, the results suggest that incorporating only one treatment of placing a microwave safe covering over the entrée as it is cooked or flipping the product halfway through the cooking process does not significantly increase the temperature of the product or lead to a more even distribution of heat throughout the entrée. While not significantly higher, those entrees subjected to both treatments of being flipped and covered did achieve higher end-point temperatures compared to those that were not, and thus may a provide a margin of safety.

Variable	P-value
Product	0.0009
Type	0.2979
Wattage	<.0001
Treatment	0.8429
Channel	0.0184

Table 8. Variables analyzed at a 0.05 level of significance. Only product, wattage, and channel are shown to be of significance.

Raw, breaded chicken entrees were prepared in both a 600 W microwave oven and a 1,000 W microwave oven. The 600 W microwave oven was chosen because it is the lowest wattage available to consumers and was frequently observed in our local retail market. The chicken tenderloins used in the observational portion of the study contained instructions that had been validated by the manufacturer using a 600 W microwave oven. In contrast, the instructions

for most stuffed, breaded chicken entrees have been validated by processors using a 1,000 W microwave oven. While most consumers possess a microwave oven, it is risky for a processor to assume that most consumers have at least a 1,000 W microwave. A consumer preparing the same product that has been validated in a 1,000 W microwave oven will most likely end up with an undercooked product if preparing in a microwave of lower wattage. However, processors caution consumers by providing the statement, "appliances vary, adjust cooking times accordingly." This guidance statement is intended to make the consumer aware that the product may not be fully cooked after preparation per package instructions. While the statement may seem beneficial, it is often times positioned within the cooking instructions in a manner which may lead to the consumer overlooking its cautionary nature. As a result, consumers only glancing at the instructions may believe that by preparing the entree per the label instructions they will end with a safe product. More importantly, the only way a consumer can determine if an adjustment in cooking time is needed is by using a food thermometer. Our observational research (Objective 2) and research by others strongly suggests that thermometer usage is very minimal, particularly with this type of product.

When chicken cordon bleus were prepared individually (Figure 7) , the filling (channel 0, probe location A in Fig. 6) of the stuffed entrees was the only channel to consistently reach a temperature greater ≥165°F. In contrast, when prepared in multiples, the end of the product containing the thickest portion of raw chicken (channel 2 or location C in Fig. 6) consistently reached temperatures greater than 165°F. Channels 0, 1 and 3 (probes positioned in locations A, B and D in Fig. 6) never reached a safe internal temperature. The probe measuring the internal stuffing revealed the lowest temperatures. Both thermocouples B and D monitored the temperature of raw chicken on the product sides. Moreover, the cold spots found within the product did not reveal a predictive pattern.

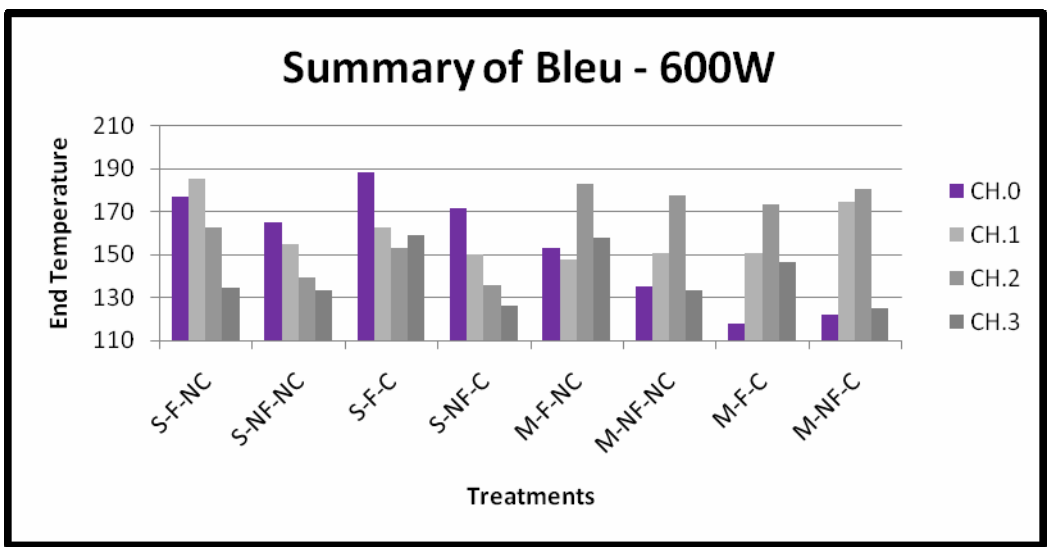


Figure 7. Comparison of chicken cordon bleus cooked individually and in multiples in a 600 W microwave oven.

Chicken cordon bleus, when prepared in multiples, consistently reached lower temperatures compared to products prepared individually. Even though the product did not reach 165°F, it had the appearance of a fully cooked entrée when cut open (Figure 8). As a typical consumer not using a meat thermometer, it would have been difficult to determine that the

temperature had not reached a safe end-point temperature. If the consumer was using color as an indicator of doneness they may have believed the product to be fully cooked and therefore safe for consumption. The other products that were used in the study also did not reach fully cooked temperatures, but did reach higher temperatures compared to the chicken cordon bleu.

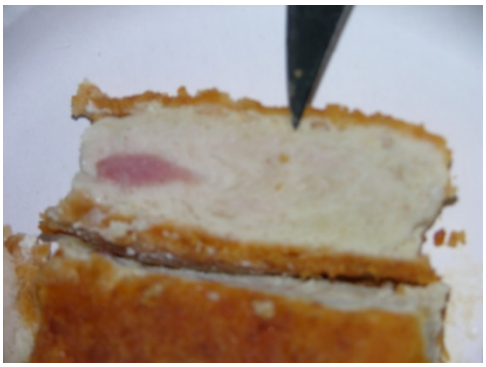


Figure 8: Example of a cordon bleu that appears to be fully cooked (based on appearance) after cooking for the suggested period of time in a 600 W microwave oven but did not reach the recommended temperature of 165°F.

Single chicken Kievs were fully cooked when covered, but not flipped and when flipped, but not covered (Figure 9). The remaining treatments produced at least two cold spots internally. Additionally, the Kievs reached higher overall end temperatures compared to the chicken cordon bleus under the same treatment conditions prepared in a 600 W microwave oven. When prepared in multiples, only one treatment (combination of covering and flipping) resulted in the chicken Kievs achieving a fully cooked status. However, those treatments that resulted in a fully cooked product when cooked individually did not do so when cooked in multiples.

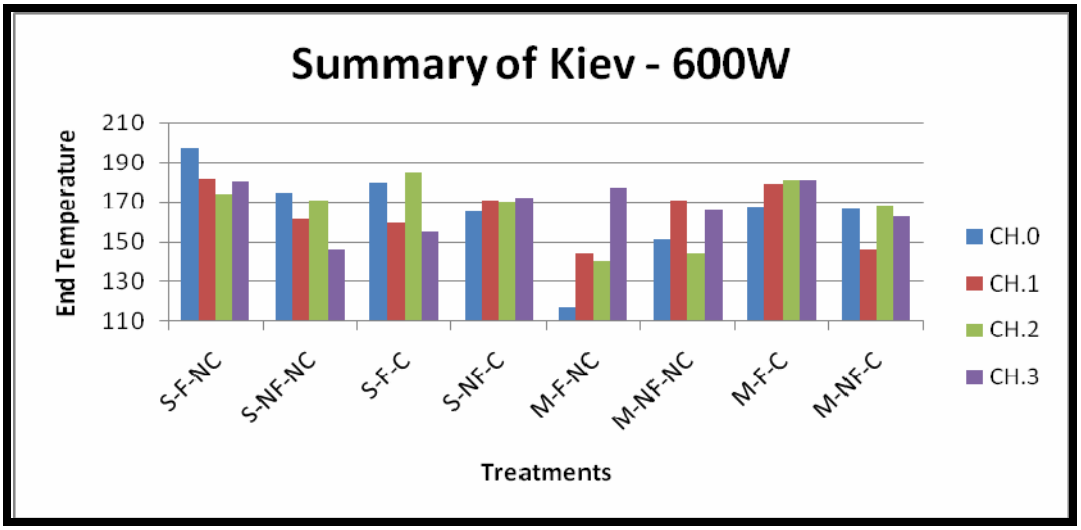


Figure 9: Comparison of the chicken Kievs cooked individually and in multiples in a 600 W microwave oven.

The chicken tenderloins were only prepared in multiples of three. One treatment condition, M-F-NC, was the only treatment to produce a fully cooked end product using the 600 W microwave oven (Figure 10). All other treatments resulted in an undercooked entrée. The chicken tenderloins prepared in a 600 W appliance never reached 165°F. Similar to the other

breaded entrees, the tenderloins contained cold spots; however, the location of these undercooked areas was not predictable.

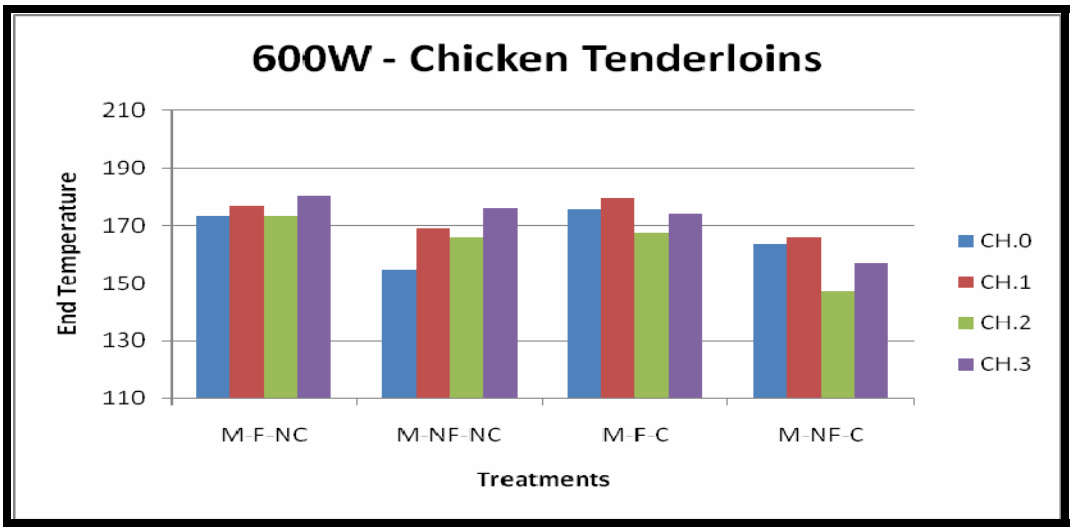


Figure 10. Comparison of chicken tenders cooked in multiples in a 600 W microwave oven.

When prepared in a 1,000 W microwave oven, the products universally reached temperatures well above the recommended 165°F (Figures 11-13). Additionally, there was a more even temperature distribution across the product.

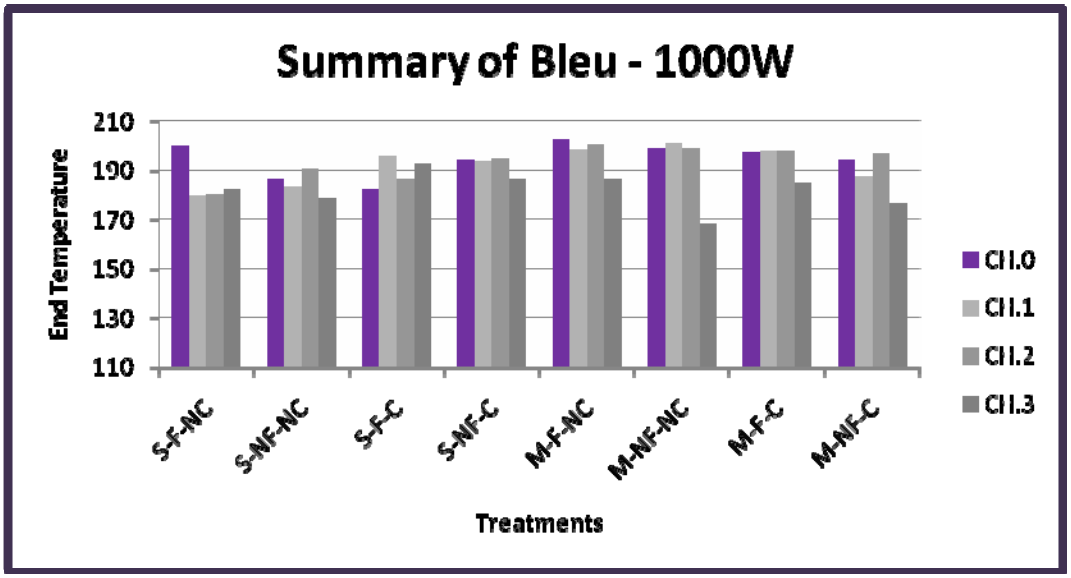


Figure 11. Comparison of chicken cordon bleus cooked individually and in multiples in a 1,000 W microwave oven.

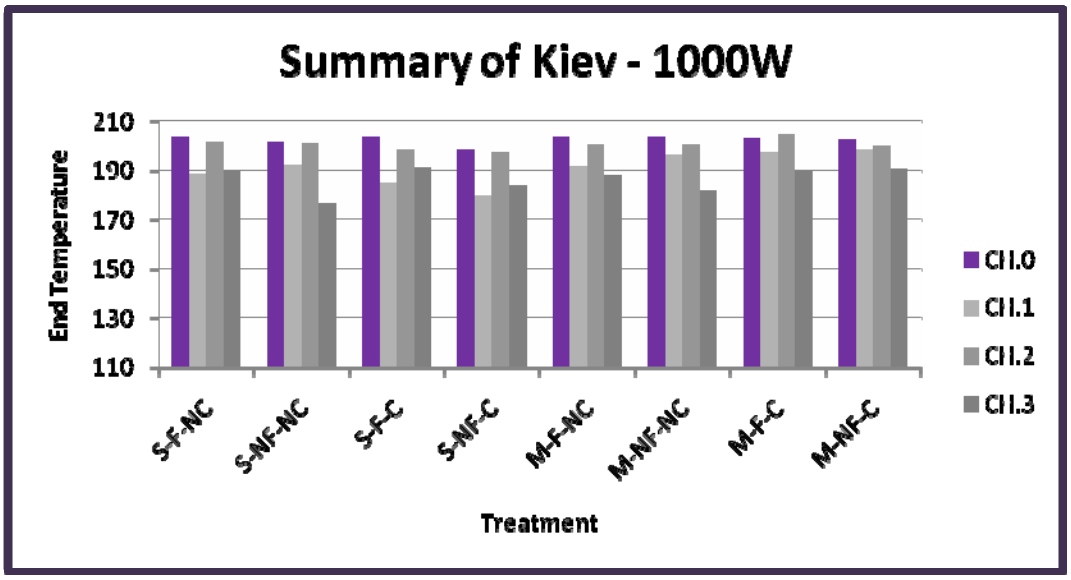


Figure 12: Comparison of chicken Kievs cooked individually and in multiples in a 1,000 W microwave oven.

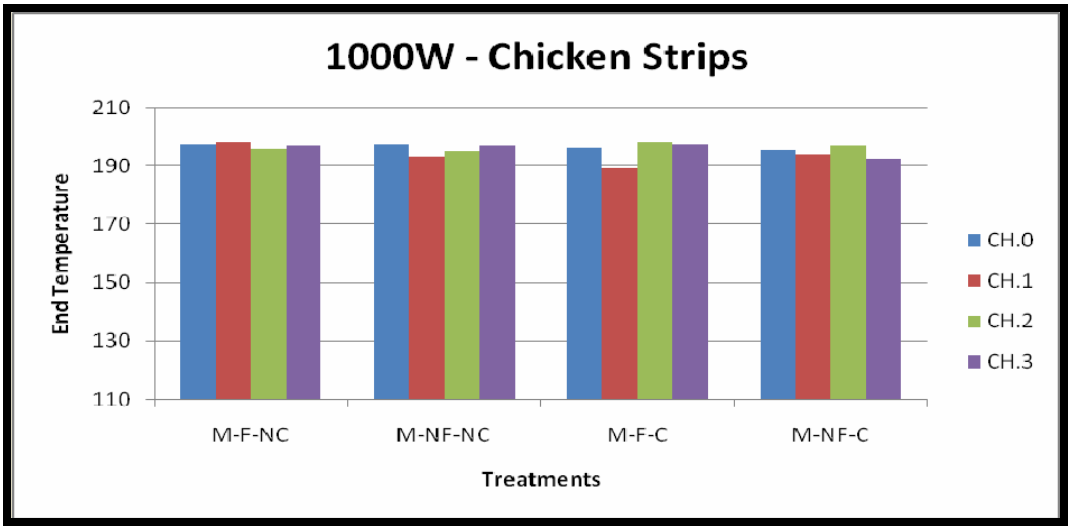


Figure 13: Comparison of chicken tenders cooked in multiples in a 1,000W microwave oven.

Conclusions:

The three products chosen for the study have all been implicated in previous outbreaks of salmonellosis linked to raw, breaded chicken entrees. From this temperature profiling study, it appears that the primary product of concern is the chicken cordon bleu. At this point, we are further researching the possibility of the specific heat of the individual product constituents to determine the role it plays in the overall heating of the product during microwave cooking. We are hypothesizing that certain components of the chicken cordon bleu have a higher specific heat than the other products, thereby, requiring more energy to fully heat the product (particularly from a frozen state). If true, this may offer some explanation as to why the other products reach higher end-point temperatures when prepared in a 1,000 W microwave oven versus a 600 W microwave oven.

Based on the studies completed thus far, raw, breaded chicken entrees should not be prepared in a microwave oven. However, if the conventional oven is not an available option the microwave oven used for preparation should not be less than a 1,000 W. Low wattage preparation results in a product that poses a significant risk for consumption. The only effective way to ensure that the product is fully cooked is to use a food thermometer appropriate to the specific product; however, information based on our observational study confirms that consumers tend to very frequently ignore statements provided on product packaging which encourages them to check the internal temperature in multiple locations. Also, recent observations have revealed that some processors are no longer instructing consumers to check the temperature in multiple locations, but instead only at the thickest portion of the entrée. This recommendation is misleading for two reasons. First, the center portion of this product type is comprised of fully cooked filling. Secondly, this study demonstrates that this portion reaches higher temperatures compared to the raw chicken portion of the entrée. The lower wattage microwaves simply do not provide enough power for the product to heat sufficiently in the cooking times as confirmed by the results of this cooking study.

Consumers most likely do not read the package statement defining the wattage at which the specific product's cooking instructions were validated. Additionally, many consumers are unaware of the wattage of their microwave ovens.

As mentioned previously, eight boxes containing microwaving instructions were still available six months after label changes were implemented. Those boxes providing microwaving instructions were mixed with the same product that had removed such instructions, with no other discernable changes in product packaging. This mishap provides distinct opportunity for consumer confusion as they could possibly misinterpret label instructions if purchasing multiple boxes. Also, while purchasing the entrees and on several subsequent occasions, we noticed the placement of fully cooked products shelved directly next to raw products.

Processors have actively responded to aforementioned outbreaks by removing microwave instructions from the product packaging; however, outbreaks continue to be detected suggesting consumers are still preparing the products in the microwave oven regardless of recent changes in cooking methods recommendations. As a result of the study, our recommendations are as follows:

- Raw, breaded chicken entrees should not be prepared in a microwave oven of less than a 1,000 W;

- Processors should validate label instructions on a range of different wattages based on consumer availability;

- Grocers must be vigilant in and accountable for removing re-packaged/re-labeled products from retail cases; and

- Consumers, to the best of their ability, should follow recommended cooking instructions in their entirety; especially use a quality food thermometer to determine final product temperature.

Phase II Methodology (*Salmonella*-Inoculated Cooking Study):

Identical products were chosen for this study for effective comparison to the findings of the previous Phase I Cooking Study: Chicken Tenders, Chicken Cordon Bleus, and Chicken Kievs. Products used in this study were the same brand, processed in the same facilities as those in recently completed related studies, and readily available at local retail grocers. Cooking treatments were applied as indicated in Table 2.

A five serovar cocktail of *Salmonella* spp. inoculum was prepared on the day of inoculation using three separate batches of cultures, grown in 30 ml of Tryptic Soy Broth (TSB) and incubated at 35°C for 24 hours. Since all products were inoculated on the same day, each of three separate batches of inoculum was prepared that same day as well. Each of the five cultures for the separate batch was centrifuged in a Beckman centrifuge, using a JA-14 rotor for 15 minutes, at 5,000 x g and -4°C. Supernatant was then drained from the centrifuge bottle, and the pure *Salmonella* pellet was rehydrated using 5.0 ml of 0.1% peptone water diluent. The rehydrated cell pellets were combined and homogenized to complete preparation of the master inoculum. This protocol was repeated for the remaining two batches of inoculum required.

Each product was inoculated by injection using a tuberculin syringe depositing 0.025ml of master inoculum into each of 10 pre-defined locations throughout the product (Figure 14), for a total of 0.25 ml of inoculum per product (providing approximately 6 log cfu/g of product). Preliminary moisture measurements were completed with each product type to ensure that this level of added fluid would not significantly alter the percentage of moisture to the remaining product constituents. Immediately following inoculation, each product was returned to its original packaging, and frozen at -14°C until such time as needed for analysis.

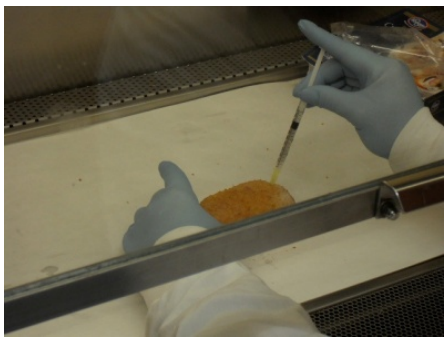


Figure 14: Prepared *Salmonella* spp. inoculum being injected into 10 pre-determined locations of each raw, frozen, stuffed and breaded poultry entree.

Cooking instructions were followed to precisely mirror those in the preceding Cooking and Observational studies, directly related to this portion of the project. Products were prepared using the same microwave ovens used in the Cooking Study: 600W Daewoo, Model No. KOR-6LOB and 1000W Kenmore, Model No. 721.66029500. It is important to note that performance testing on these ovens was not completed between utilization of these ovens for the two separate studies, and may have a minor effect on the overall results. However, we also believe that this potential decrease in power with increased usage may also mimic the more realistic performance of consumer microwave ovens within the home when used over a significant period of time.

Note that for products cooked as "singles", five thermocouples were used to monitor temperature immediately upon removal from the microwave oven, while only four were used in the Phase I Cooking Study. This fifth thermocouple was used to monitor the chicken temperature on the top portion of the product, as we had previously noticed this to be a visibly uncooked area in the Cooking Study, as illustrated in Figure 15, but did not have thermal data to relate to visual observation at that time.

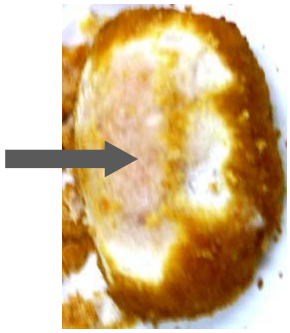


Figure 15: Chicken cordon bleu (breading removed) with fully cooked temperatures verified at most monitored thermocouples, but clearly undercooked at top of product (indicated by arrow).

Once the two-minute post-cook holding period was complete as per package instructions, during which time the thermal characteristics were monitored by thermocouples sending precise temperature data to the USB-TC data logging system, the entire product was immediately removed from the plate and placed into a stomacher bag. The bag was promptly placed into a basket suspended in an insulated cooler filled with ice water to chill the product to a non-lethal temperature. Each product was chilled for approximately 5 minutes. Peptone water (0.1%) diluent (225 ml) was added to each whole sample entrée and blended for 2 minutes in a Stomacher 400 lab blender. Samples were then analyzed using standard spread plating technique with duplicate plating onto Xylose Lysine Desoxycholate (XLD) and Non-Selective Nutrient Enriched Tryptic Soy Agars (NS). The sample plates were incubated for 24 ± 2 hours at 35°C prior to counting presumptive *Salmonella* colony forming units. Plating agars used were chosen as a result of the selective characteristics of XLD for *Salmonella* detection which allows enumeration of healthy organisms, while the NS agar makes a traditionally non-selective agar differential for *Salmonella*, encouraging growth of the organisms that may be injured during the by non-lethal processing temperatures. This differentiation gives us the ability to compare treatments based on death and/or injury of *Salmonella* microorganisms in the product. Each sample that resulted in no visible cfu's during spread plating was further analyzed using RapidChek® SELECT™ *Salmonella* ELISA (Enzyme Linked Immunosorbent Assay) dual enrichment assays (Strategic Diagnostics Inc.) to detect very low survival.

Results:

The overall statistical design for both microbial and temperature data was a randomized complete block design, with the day of repetition as the blocking factor. Single samples and multiple samples were analyzed separately for all analyses in both microbial and temperature

data. For microbial (*Salmonella*) recovery, two analyses were conducted separately for each media used for enumeration. The first analysis was conducted separately for each product and included the uncooked control for that product. Therefore, the treatment structure for this analysis was a 2 (flip) x 2 (cover) x 2 (wattage) factorial, plus the control. When the overall treatment F-test was significant, Scheffe's test was used to compare the uncooked control to the remaining eight treatments. Scheffe's test was used instead of Dunnett's test to prove a more conservative test (i.e., lower Type 1 error rate) in comparing cooked and uncooked samples. The second analysis for microbial data excluded the uncooked control, resulting in a treatment structure of 3 (product) x 2 (flip) x 2 (cover) x 2 (wattage) factorial for multiple samples and a 2 (product) x 2 (flip) x 2 (cover) x 2 (wattage) factorial for single samples. For the multiple samples, if the overall product F-test was significant, LSD pair-wise comparisons were conducted for product means. All analyses were performed using a MIXED procedure of SAS® (SAS Institute, 2007) using a significance level of $p \leq 0.05$ (95% confidence interval). Therefore, the values of importance in our comparison between "UNCOOKED" and "COOKED" products where those that did not result in a p value ≤ 0.05, and so did not show a statistically significant difference between the inoculated uncooked control sample, and the inoculated cooked samples.

For each of minimum, maximum and mean temperatures, a preliminary repeated-measures analysis was conducted using the GLM procedure of SAS® with channel as the repeated measures factor. Results indicated that an analysis with channel as a split-plot factor was appropriate. Therefore, temperature data were analyzed as a randomized complete block design with a split plot. The whole-plot treatment structure was a 3 (product) x 2 (flip) x 2 (cover) x 2 (wattage) factorial for multiple samples and a 2 (product) x 2 (flip) x 2 (cover) x 2 (wattage) factorial for single samples. Channel (at 4 levels for multiple samples at 5 levels for single samples) and all interactions with whole-plot treatment factors were the effects on the split-plot. For multiple samples, if the overall product F-test was significant, LSD pair-wise comparisons were conducted for product means. Similarly, for both single and multiple samples, LSD pair-wise comparisons were conducted for channel means if the overall channel F-test was significant. Analyses were conducted using the MIXED procedure of SAS®, utilizing a significance level of $p \leq 0.05$ (95% confidence interval).

Products prepared in the 600 W microwave oven consistently resulted in non-significant ($p > 0.05$) values, indicating that there was not a significant difference in *Salmonella* recovery in these products as compared to the inoculated uncooked control product. Note that the values reported below are representative of healthy colonies able to grow on XLD agar. Approximately 0.5 to 1.0 log higher counts of potentially injured organisms were counted on the NS agar in the 600 W sample categories. Figures provided below do not illustrate results of products cooked in the 1000 watt microwave oven, as none of those treatments were statistically significant, and nearly all samples produced no visible cfu's in standard spread plating techniques.

Salmonella spp. were recovered from all treatments used to cook chicken tenders except the flip and cover combination treatment (Figure 16).

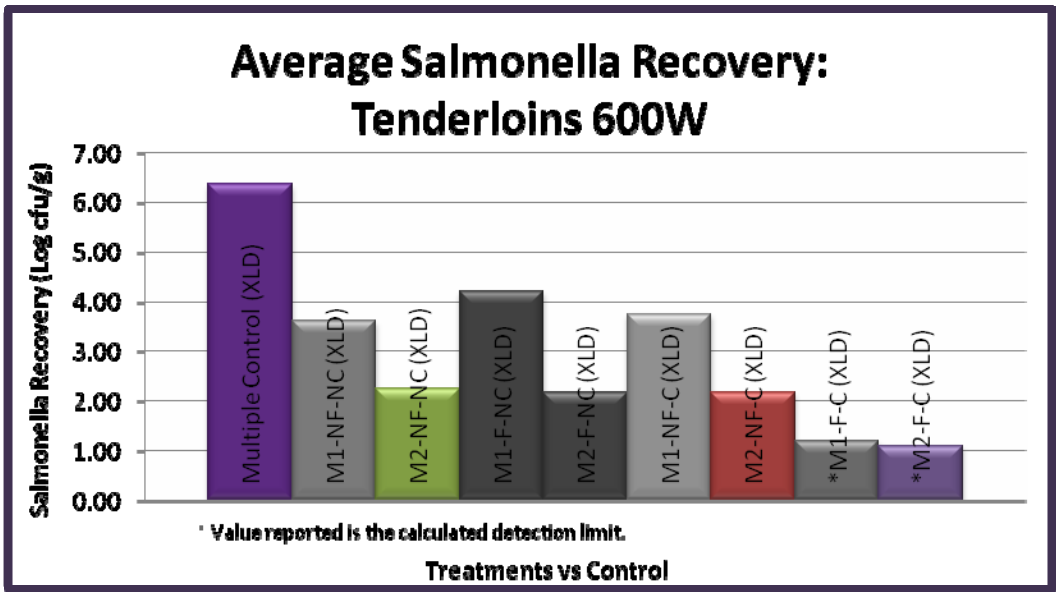


Figure 16. Comparison of *Salmonella* recovery for chicken tenderloins cooked in a 600 W microwave oven**.**

Viable *Salmonella* spp. were detected from all treatment combinations after cooking (Figure 17), indicating that none of the cooking protocols yielded at validated process to control *Salmonella*. Chicken cordon bleus resulted in the highest level of *Salmonella* spp. survival compared to the other two products.

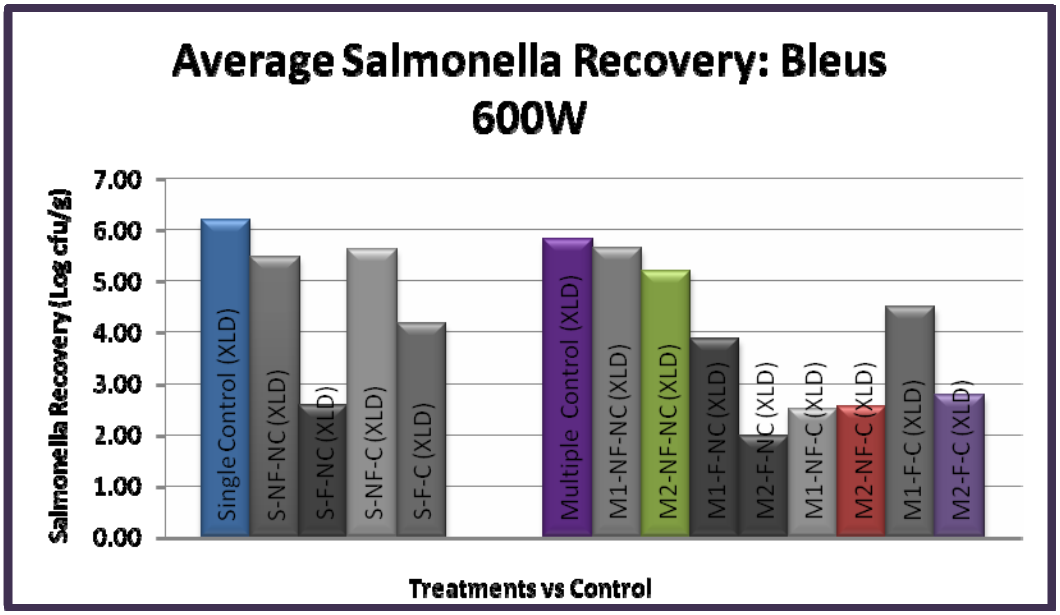


Figure 17. Comparison of *Salmonella* recovery for chicken cordon bleus cooked in a 600 W microwave oven**.**

Similar to observations for chicken cordon bleus,, a high level of Salmonella spp. survival was determined for chicken Kievs cooked with 600 W microwave oven (Figure 18).

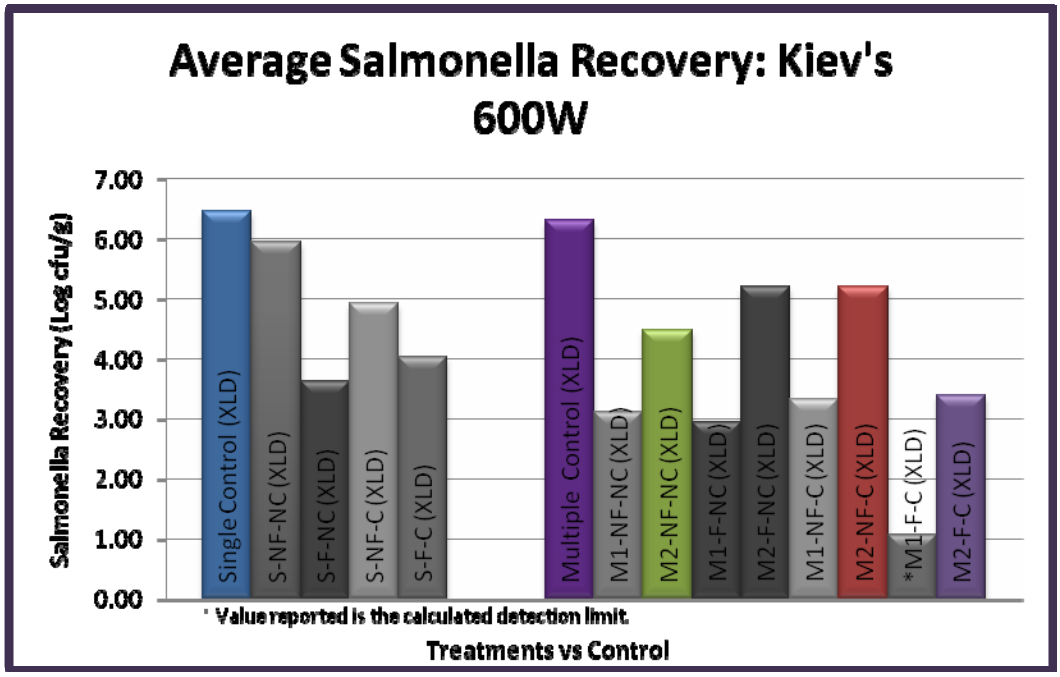


Figure 18. Comparison of *Salmonella* recovery for chicken kiev's cooked in a 600W microwave oven.

We were also able to ascertain that, when cooked in multiples, there is a significant difference in temperature of the inner channel between the two products, regardless of treatment, product or wattage (Figure 19).

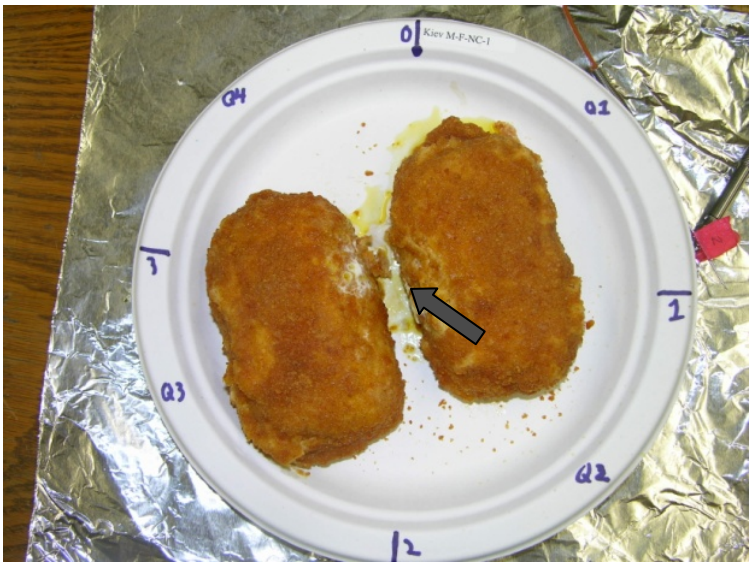


Figure 19: Chicken Kiev cooked in multiples of two. Arrow indicates "inner" area where significant temperature variation was detected.

Conclusions:

Our research has consistently shown, thus far, that there is no predictable pattern of heating for raw, breaded and stuffed poultry products when cooked in the microwave oven at 600 or 1,000 W. Although products cooked in a 1,000 W oven did not result in visible colonies at or above our detection limit, many of these entrees did produce a presumptive positive result when tested using ELISA enrichment methods (meaning a very low level of survival). Noting that only 100 to 1,000 *Salmonella* spp. organisms can cause infection (depending on serovar present and health status of the individual) and that this number may be even smaller in children, elderly and otherwise immune-compromised consumers, products that may contain *Salmonella* at even a low level pose a considerable health threat to the consumer and equally significant economical impacts to this sector of the food industry. Products prepared in a 600 W microwave oven consistently produced a much higher recovery of *Salmonella*, indicating that wattage is, in fact, a highly significant factor in product preparation for food safety. As is consistent with previously completed related research, treatment appears to be only a minor factor in the overall heating process for these product types. The only treatment that seemed to have any consistent positive effect on the level of recovery under low-wattage conditions is flipping/no cover, regardless of product. Additionally, our research also shows that there is a consistent difference in *Salmonella* recovery when comparing products cooked in multiples, to mirror the variation shown earlier in temperature variation at the inner area of measurement, and thus could provide a greater element of risk.

Overall Project Conclusions:

1) Foodborne illness outbreaks associated with these products continue to emphasize the risk factors linked to frozen, raw, breaded and/or stuffed chicken entrees. Many consumers remain under the impression that these products are fully cooked at the time of purchase and need only to be reheated. Fully cooked, pre-browned and uncooked products are frequently placed in close proximity in retail frozen foods displays, as well as very similarly packaged in many cases. Most recently, we found these products in single-serving cellophane wrappings, costing less than $1.00 each, and placed directly next to fully cooked products. When fully cooked and raw, pre-browned versions of the same products are available the raw, pre-browned product is generally less expensive, and thus more appealing to budget-conscious consumers.

2) Consumers continue to use preparation methods not specifically suggested by processors of these products, suggesting that statements discouraging product preparation in a microwave oven and promoting food thermometer use are not widely effective as currently being delivered on packages. Even the small percentage of consumers who attempted to follow safe handling guidelines failed to do so correctly in our consumer study. While an admirable and proactive step by industry leaders, removing microwave instructions from preparation recommendations has not prevented illnesses from being linked to this product category. A contributing factor

to this is likely a consumer preference and tradition of utilizing a microwave oven to prepare these convenience oriented products. Further, we found that adolescents (a likely user of these products) were more likely to make critical preparation and cross-contamination mistakes in the kitchen.

3) Cooking studies using microwave ovens commonly found in retail (600 and 1,000 W) revealed that uniform heating is not achieved in this product category regardless of additional treatments such as flipping or covering products during cooking. Heating frozen single or multiple (two Kievs/cordon bleus and three chicken strips) units at one time in the microwave did not significantly impact heating uniformity or final product temperatures achieved. Microwave ovens of wattages below 1,000 W are readily available and reasonably priced for the average consumer based on our casual observations in local retail outlets and the internet. Our thermal profiling data clearly reveals that preparation in lower wattage ovens significantly increases the potential for an undercooked product that may lead to illness. In fact, in inoculated trials, *Salmonella* spp. was consistently recovered from all products prepared using the 600 W microwave oven when analyzed directly after cooking.

Future Research Recommendations:

The CDC (Centers for Disease Control and Prevention) reports on their website that 1.4 million cases of salmonellosis still occur each year, including approximately 40,000 culture-confirmed cases and over 400 fatalities. It is imperative that government, industry, and academic researchers work together to improve current processing and preparation methods to help each other protect a continuously dependent, and increasingly demanding, consumer.

As this product type is increasing in availability, variety of filling, packaging techniques and marketing approaches, our recommendations for further collaborative, multi-disciplinary research studies in an effort to:

- Determine thermal effects of various product fillings during microwave heating (analytical determination of specific heat for different product components);
- Evaluate the spectrum of microwave engineering in currently available machines and determine efficacy of each general design in product safety and heating;
- Evaluate new and upcoming technologies in microwave cooking which may aid in product safety;
- Determine variability in the performance of typical consumers' microwave ovens due to age of the appliance and loading of circuits in home kitchens to determine any increased safety risks; and,
- Better understand effective and practical ways to deliver compelling food safety handling information for this product category to consumers and food service operations.

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