MICROWAVE INSTRUCTIONS FOR PREPARED BUT NOT READY-TO-EAT FOODS – IT'S JUST NOT WORTH THE RISK

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I. INTRODUCTION

Current consumer trends indicate half of all suppers are prepared in 30 minutes or less[1] and nearly 4 out of 10 dinners are determined just prior to meal preparation.[2] Our fast paced society has pushed food processors to look for innovative foods and processes to deliver this convenience to the consumer. A group of products known as "Prepared but not ready-to-eat" products (PNRTE) have been offered by some processors as a solution for consumer's demand for convenience. PNRTE foods contain at least one ingredient for which the manufacturer can not assure vegetative pathogens have been eliminated.[3] Some companies have developed microwave instructions for these PNRTE foods which may contain raw meat, poultry and/or produce. While microwave cooking of these PNRTE products helps meet the time constraints consumers place on processors, history has shown the combination of microwave variation, inadequate

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[1] The NPD Group, Inc. (2007a). The NPD Group's Twenty-Second Annual Report on Eating Patterns in America.

[2] The NPD Group, Inc. (2007b). The Changing Dinner Plate.

[3] Scott, J., L. H0ntz, & Y. Chen (January 24, 2007). Guidelines for Validation of Consumer Cooking Instructions for Not Ready-To-Eat Products. Symposium - Prepared *But Not Ready-To-Eat Foods - What You Need to Know*. Arlington, Virginia. http://www.foodprotection.org/meetingsEducation/Timely%20Topics/Scott.pdf (last viewed 10/12/08)

directions and the consumer's failure to follow directions is an accident waiting to happen. As a food company, promoting microwave cooking of these PNRTE products is a risk not worth taking.

Section I of this paper will look at microwave heating to understand how microwave ovens heat as well as some of the factors which can cause variability in the heating process. Section II will look at the ability of microwave cooking to kill pathogenic bacteria. Section III will discuss foodborne illness outbreak case studies involving PNRTE foods and the common factors shared in each of these outbreaks.

II. MICROWAVE HEATING

To better understand the risks associated with cooking PNRTE products in microwaves it is important to understand how a microwave oven heats and what factors can influence the heating profile of a product as it is cooked in a microwave.

A. How microwaves heat

Microwave heating, also know as dielectric heating, is non-ionizing radiation composed of a magnetic and electric field oriented 90° to each other. The electronic field causes polar molecules such as water to reverse polarity, or vibrate, approximately 2.5 billion times per second.[4] This molecular excitation allows for rapid heating of the

[4]Heddleson , R. A. & S. Doores (1994). Factors affecting microwave heating of foods and microwave induced destruction of foodborne pathogens - a review. *Journal of Food Protection: 57 (11) 1025-1037.*

outer inch or so of a product. Aside from the outer edges of the product, the remainder of the product heats via conduction or convection (liquid) heating similar to how a product would heat in a conventional oven.[5] Heating by both dielectric and conduction or convection heating results in the rapid heating of food products.

B. Microwave heating variation

Products heated in microwave ovens tend to heat unevenly. The uneven heating can be in the form of cold spots within the product or varied heating results from run to run in the same oven. Some of the variation is influenced by the food product - package interaction, while part may be influenced by the microwave and how it functions. Intrinsic product factors capable of influencing temperature variability when cooked in microwave ovens can include the product moisture, salt level (ionic strength), solids content[6], weight, container shape, and density.[7] Products with higher moisture levels tend to heat more uniformly and rapidly than dryer products. Increased salt levels tend to reduce the depth of penetration of microwaves resulting in slower heating and more

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[5] Aitken, C. & D. Ironmonger (1996). Impacts of the Domestic Microwave Oven. *Prometheus,* 14, 168 - 178.

[6] Heddleson , R. A. & S. Doores (1994). Factors affecting microwave heating of foods and microwave induced destruction of foodborne pathogens - a review. *Journal of Food Protection: 57 (11) 1025-1037.*

[7] Davidson, P. M. (January 24, 2007). Factor that Influence Microbial Inactivation During Microwave Cooking. *Symposium - Prepared, But Not Ready-To-Eat Foods - What You Need to Know*. Arlington, Virginia. http://www.foodprotection.org/meetingsEducation/Timely%20Topics/Davidson.pdf (last viewed 10/12/08)

temperature variability in the product. The container geometry can either enhance heating uniformity or exaggerate the variability. Sharp corners tend to focus the microwave energy in the corners resulting in hot spots in the package. Spherical shaped packaging tends to promote uniform heating.[8]

Oven related factors such as the power wattage, oven cavity size and shape, supply voltage variability, and reduced power output with prolonged operating time can all contribute to cooking variations as well.[9] The phenomenon of reduced power over a prolonged operation time was demonstrated by M.J. Swain et al. when they tested multiple ovens from both a "cold" (ovens not used for over 6 hours) and "hot" (ovens that had been run for 15 minutes prior to testing) state. The end point temperature of similar product cooked for the same amount of time was monitored from "hot" ovens and "cold" ovens. An average product end point temperature variation of 9°C was observed between the "hot" and "cold" ovens with the warmest temperatures observed in products cooked in the "cold" ovens.[10]

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[8] Heddleson , R. A. & S. Doores (1994). Factors affecting microwave heating of foods and microwave induced destruction of foodborne pathogens - a review. *Journal of Food Protection: 57 (11) 1025-1037.*

[9] Hooper, G. (January 24, 2007). Factors That Affect Microwave Power and Issues with the Uniformity of Heating in Ovens. *Symposium - Prepared, But Not Ready-To-Eat Foods - What You Need to Know*. Arlington, Virginia.

[10] Swain, M. J., S. J. James, & M. V. L Swain (2008). Effect of power output reduction of domestic microwave ovens after continuous (intermittent) use on food temperature after reheating. *Journal of Food Engineering: 87 (1, CHISA 2006 Special Section (pp. 1-63) Selected*

III. Research Indicating Potential Food Safety issues when Cooking NRTE Products in Microwaves

The scientific community has conducted considerable research on the ability of microwave cooking to kill pathogenic bacteria. Described here are studies which evaluate the topic of thermal destruction of pathogens with microwave cooking. These studies highlight some of the risks associated with cooking raw or PNRTE products in a microwave oven.

A. Survival of Listeria spp. on Raw Whole Chickens Cooked in Microwave Ovens

Whole raw broilers ($\leq$1.8 kg) and whole raw roasters (>1.8kg) were cooked in 17 different microwave ovens from various suppliers representing a range of power from 500 – 800 watts and a cavity size range of 0.6 to 1.3 ft^3. The chickens cooked in this study were naturally contaminated with *Listeria* spp. (not inoculated) and cooked according to the microwave manufacturer's directions.

In this study 81 broiler chickens tested positive for *Listeria* spp. prior to being cooked in the various microwave ovens. After cooking, one of the broilers tested positive for *Listeria*. As part of the same study, 93 roasters which tested positive for *Listeria* spp. were also cooked in the same 17 microwave ovens. After cooking, nine of

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papers from the symposium 'Food Processing and Technology' held at the 2006 CHISA Congress, Prague, Czech Republic) 11-15, 87**,** Selected-15.

the roasters tested positive for *Listeria*. Two of the seventeen microwave ovens accounted for 7 of the 10 positive cooked samples. The remaining three positive samples were from three different microwave ovens. Six temperatures (two from the thigh, two from the breast and 2 from the back) were measured from each bird after the prescribed resting period (either 10 or 15 minutes) after cooking. Of the cooked birds testing positive for *Listeria* spp., the bird with the coldest post-rest temperatures ranged from 40.4 – 48.6°C while the hottest bird had a post-rest temperature range of 87.1 – 100.2°C.[11]

The instructions used for cooking these whole chickens were developed specifically for each microwave oven tested by their manufacturers, yet 5.7% of the cooks resulted in product that remained positive for *Listeria*. This level of undercooked product demonstrates the variability associated with microwave cooking even under what could be considered the best (microwave instructions developed by the manufacturer of the microwave) scenario. Also demonstrated was the marginal ability of microwave cooking to eliminate natural levels of pathogenic bacteria (10/174 birds positive after cooking).

B. Survival of Bacteria in Food Cooked by Microwave Oven, Conventional Oven and Slow Cooker.

Meatloaf emulsion was inoculated with a variety of pathogenic bacteria. The

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[11] Farber, J. M., J. Y. D'Aoust, M. Diotte, A. Sewell, & E. Daley (1998) .Survival of Listeria spp. on

emulsion was divided equally into thirds and cooked via a microwave oven, a conventional oven and a slow cooker. The results from this study showed a higher log reduction of pathogens for the product cooked in the conventional oven and slow cooker when compared to the pathogen log reduction of product cooked in the microwave oven. Log reductions of 2.27, 2.75, and 1.29 were measured for the conventional oven, slow cooker and microwave oven, respectively when all products were cooked to 75°C. The microwave oven is sufficient to reduce incidental contamination or low level contamination to an acceptable level, whereas the slow cooker was an excellent process for rendering contaminated foods safe due to the long time exposure at higher temperatures. The rapid rise in temperature due to microwave heating did not result in the same kind of time/temperature thermal destruction the conventional oven and slow cooker delivered.[12]

The degree of safety demonstrated with conventional oven cooking is not present to the same extent when cooking with a microwave oven. Products with a high pathogen load may over load the lethality the microwave cooking process can deliver, resulting in the potential for foodborne illness if the product is consumed.

C. Injury of Salmonella Species Heated by Microwave Energy

Milk and beef broth were inoculated with a 5 strain cocktail of various *Salmonella* serotypes at a level of 10^6 cfu/ml. The solutions were heated in a

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raw whole chickens cooked in microwave ovens. *Journal of Food Protection: 61 (11) 1465-1469.*

[12] Fruin, J. T. & L. S. Guthertz (June 1982) .Survival of Bacteria in Food Cooked by Microwave

microwave oven to a "mixed" endpoint temperature ranging from 64 – 74°C. At the end of heating, the solutions were either stirred immediately and samples taken or allowed to sit undisturbed for 5 or 10 minutes before sampling. The samples were incubated at 25°C for up to 72 hours before plating in an effort to recover injured cells.

The greatest destruction of *Salmonella* was obtained when the solution was stirred immediately after heating with no standing time. When the product was allowed to sit for 5 or 10 minutes prior to stirring and sampling, Salmonella was isolated at every temperature variable.[13]

The simple act of stirring the solution at the end of the cook illustrates the importance of following preparation directions. Failing to stir the product immediately after cooking allowed for the survival of *Salmonella* even when heated to an average temperature of 74°C.. Translating this concept to cooking instructions shows how failing to follow instructions such as; hold times, stirring half way through the cook time or failing to cover the product while heating may all lead to product that is insufficiently cooked.

IV. FOODBORNE ILLNESS OUTBREAK CASE STUDIES

The risk of cooking PNRTE products in a microwave goes beyond the research of the scientific community when a product is positioned for sale to the consuming public.

Oven, Conventional Oven and Slow Cooker. *Journal of Food Protection*, 45, 695 - 698.

[13] Heddleson , R. A. & S. D00res (1994). Factors affecting microwave heating of foods and microwave induced destruction of foodborne pathogens - a review. *Journal of Food Protection: 57 (11) 1025-1037*.

In addition to microwave oven variability and the innate variability in microwave cooking, the human factor is added. The human factor is present at both the manufacturing level and at the consumer level. Has the company developed microwave cooking instructions that are properly validated and written so they are easy to follow? Does the company identify the product as raw and needing to be fully-cooked? Does the consumer know the power level of their Microwave oven? Does the consumer understand that the product needs to be fully cooked? Does the consumer read and follow the heating instructions? The following are foodborne illness outbreak cases involving PNRTE products which have been associated with microwave oven processing.

A. Salmonella Heidelberg Outbreak Associated with Chicken Nuggets and Strips in British Columbia, Canada

Twenty - three cases of *Salmonella* Heidelberg were identified in early 2003 in British Columbia, Canada. Interviews with individuals from this outbreak implicated frozen chicken nuggets or strips as the source of the outbreak. Of the 23 cases, 65% sought treatment in the emergency room, 45% ended up in the hospital and 40% had bloody diarrhea. *Salmonella* Heidelberg which matched the outbreak strain was isolated out of opened and unopened packages of the chicken products.

Of those case members interviewed, more than 30% considered the chicken nugget products and products similar to it, precooked and only needing to be warmed

up. Over 25% of the members either always or sometimes used a microwave to prepare this type of food. [14]

B. Frozen pre-browned stuffed chicken products

The Minnesota Department of Health (MDH) published a news release on October 3, 2008 notifying the public of 14 *Salmonella* cases which were associated with Chicken Kiev and Chicken Cordon Blue produced by Milford Valley Farms. This outbreak was the 6th outbreak reported by the MDH since 1998 involving raw, pre-browned, frozen, stuffed chicken products such as these.[15] Following a similar outbreak and recall in March 2006, the MDH issued a press release notifying Minnesota consumers of the issues with pre-browned, stuffed raw chicken products and advising them against cooking these types of products in microwave ovens. The MDH issued this statement in its 2005 annual summary:

> In order to prevent future outbreaks, we recommend that microwave instruction should be removed entirely from the label, that these products are fully cooked prior to sale, or that these products are irradiated prior to sale.[16]

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[14] MacDougall, L., M. Fyfe, L. McIntyre, A. Paccagnella, K. Cordner, A. Kerr, & J. Aramini, (2004). Frozen chicken nuggets and strips - a newly identified risk factor for *Salmonella* Heidelberg infection in British Columbia, Canada. *Journal of Food Protection: 67 (6) 1111-1115.*

[15] Minnesota Department of Health News Release, October 3, 2008. http://www.health.state.mn.us/news/pressrel/salmonella100308.html : (Last Viewed October 5, 2008)

[16] Minnesota Department of Health Infectious Disease Epidemiology, Minnesota Department of Health 2005 Gastroenteritis Outbreak Summary. Saint Paul, MN 55155-2538, Minnesota Department of Health. http://www.health.state.mn.us/divs/idepc/dtopics/foodborne/outbreak/outbreaks2005.pdf (last viewed 10/12/08)

In addition to the MDH news release on October 3, 2008, the USDA issued a Public Health Alert for "Frozen, Stuffed Raw Chicken Products". The outbreak was expanded to 12 states including Minnesota with the total number of illnesses at 32 cases. The product involved no longer had microwave instructions on the package and clearly identified the product as being raw. "Individuals who became ill did not follow the cooking instructions and reportedly used a microwave to prepare the product."[17]

C. Banquet™ Pot Pies

In 2007 the largest outbreak involving a PNRTE product occurred. An outbreak of *Salmonella* I 4, [5], 12:i:- was associated with Banquet brand pot pies along with 8 other private label brand names. A total of 401 confirmed cases in 41 states were reported. Approximately 50% of the victims had bloody diarrhea and 30% were hospitalized. Of the victims interviewed, 75% cooked the pot pie in a microwave, 19% cooked more than one pie at a time in the microwave, 37% failed to follow the directions and allow the product to sit for the appropriate time after microwaving.[18]

The cooking instructions were confusing to many of the victims. On the front panel of the package there was a flag that stated "ready in 4 minutes". The cooking instructions read as follows:

> (Ovens may vary. Cook times may need to be adjusted)

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[17] United States Department of Agriculture (USDA) News Release, October 3, 2003, http://www.fsis.usda.gov/News_&_Events/NR_100308_01/index.asp (last viewed 10/6/08)
[18] Mody, R. (2008a) . CDC EIS Officer. *International Association ForFood Protection.* Columbus, OH.

Microwave on High
Medium or High Wattage ovens 4 minutes
Low wattage microwave 6 minutes
Let stand 3 minutes
Carefully remove as product will be hot[19]

According to the CDC, 38 cases go unreported for every case of foodborne illness that is detected.[20] This would mean that nearly 16,000 people would have been affected by this outbreak. As a result of this outbreak ConAgra Foods recalled 420 million pot pies involving 9 different brand names.[21]

Joe Meyer, Director of Microbiology for ConAgra Foods spoke at the 2008 International Association for Food Protection Annual Meeting in Columbus, OH on August 4th, 2008. He spoke on the procedural changes his company had made after conducting two large recalls during the past year, one of which involved PNRTE pot pies. Meyer opened his talk by saying "I would like to say it is a pleasure being here to speak to you today, but given the circumstances ..." As a result of the outbreak involving Banquet™ pot pies, ConAgra Foods revised their HAACP program to identify

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[19] Williams, I. (January 24, 2008). Foodborne Outbreaks Associated with Prepared, But Not Ready-to-Eat Products. *Symposium - Prepared, But Not Ready-To-Eat Foods - What You Need To Know.* Arlington, Virginia. http://www.foodprotection.org/meetingsEducation/Timely%20Topics/Davidson.pdf (last viewed 10/12/08)

[20] Williams, I. (January 24, 2008). Foodborne Outbreaks Associated with Prepared, But Not Ready-to-Eat Products. *Symposium - Prepared, But Not Ready-To-Eat Foods - What You Need To Know.* Arlington, Virginia. http://www.foodprotection.org/meetingsEducation/Timely%20Topics/Davidson.pdf (last viewed 10/12/08)

Salmonella as a potential hazard. They made process and equipment changes to enhance separation of raw and ready to eat components prior to product assembly. ConAgra Foods modified the microwave cooking instructions to make them easier to understand and posted information for consumers regarding microwave cooking on their web site.[22]

D. Commonality

According to Ian Williams Outbreaknet Team Chief, for the Center for Disease Control; "Frozen, microwaveable foods are increasingly being recognized as a vehicle for Salmonella outbreaks". The common themes behind these outbreaks involving PNRTE products are:

- The products are frozen
- Typically cooked in microwave ovens
- Consumers often mistake them for fully cooked products
- Consumers fail to follow cooking instructions
- Microwave cooking instructions are not validated. [23]

According to the American Frozen Foods Institute:

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[21] White, P. (2008). USDA-FSIS. *International Association for Food Protection*. Columbus, OH.
[22] Meyer, Joseph D. (2008). ConAgra Foods. *International Association for Food Protection*. Columbus, OH.

[23] Williams, I. (January 24, 2008). Foodborne Outbreaks Associated with Prepared, But Not Ready-to-Eat Products. *Symposium - Prepared, But Not Ready-To-Eat Foods - What You Need To Know.* Arlington, Virginia. http://www.foodprotection.org/meetingsEducation/Timely%20Topics/Davidson.pdf (last viewed 10/12/08)

> Unfortunately, variability in microwaves regarding wattage, oven size, and power supply means that those very specific cooking instructions composed by manufacturers may need to be adjusted for a particular microwave oven... As a result, it is critical that consumers, microwave manufacturers and relevant groups understand the potential for breaches in safety when "not-ready-to-eat" foods are not thoroughly cooked or are otherwise improperly prepared in the microwave oven.[24]

The largest outbreak of a PNRTE product occurred just last year involving pot pie products produced by ConAgra Foods. Each one of the items listed above played a part in the outbreak involving pot pies as well as the other outbreaks described in this paper.

V. CONCLUSION

Consumers use microwave ovens on a daily basis to help prepare snacks and meals for their families. The microwave has found its niche in the US household for heating up leftovers and popping popcorn. The shortcomings of microwave cooking are magnified when multiple factors compile upon each other. The combination of raw meat or poultry containing more than an incidental pathogen load, the variability of microwave heating, the inability of consumers to follow preparation instructions and improper cooking instructions have resulted in large foodborne outbreaks. A company's brand name is its most valuable asset. Gambling a company's brand name on products endorsing the preparation of raw PNRTE products in microwave ovens by placing microwave specific cooking instructions on the package just isn't worth the risk.

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[24] Sarasin, L. G. President/CEO American Frozen Food Institute. *AFFI Advocates Better Microwave Cooking Safety*. http://articles.directorym.net/AFFI_Advocates_Better_Microwave_Cooking_Safety-a878827.html *(last viewed 10/08/08)*