

Microbial Concerns About Precooked Convenience Foods

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Introduction

In considering the microbial concerns of refrigerated convenience foods, the literature defines what the requirements are for the manufacture of safe, wholesome refrigerated convenience foods. For various reasons, the real problems reside in the implementation of these requirements into the manufacturing, distribution, retailing and consumer handling steps. In addition, our inability to predict certain future events also raises concerns, particularly with regard to new emerging pathogenic bacteria (Bauman, 1990).

Many foods that have been available to us for years, such as canned foods, dried meats and precooked frozen dinners, can qualify as precooked, convenience foods. In this presentation, we will address precooked refrigerated convenience foods, which are cooked or pasteurized. This class of foods is emerging with increasing frequency in all types of foods and often they are difficult to distinguish from traditional products. This is particularly true since the precooked, convenience foods are often displayed for sale to the consumer along with the more conventional refrigerated foods (Corlett, 1989). Examples of this class of foods include precooked BBQ meats, precooked roast beef, refrigerated stews, pasta style entrees, as well as food packaged by the "sous-vide" process (cooking and rapid chilling following vacuum packing) (Anonymous, 1988; Beauchemin, 1990).

Characteristics of Refrigerated Precooked Convenience Foods

The general characteristics of refrigerated precooked convenience foods are:

1. Further cooking is unnecessary. The food has been adequately cooked to make it appetizing and safe microbiologically for immediate consumption, though they are often reheated for the aesthetic purposes of the consumer. However, such foods are not sterile and there is residual microflora present. Because of the mild heat treat-

ment, bacterial spores and sometimes relatively resistant vegetative bacteria survive the process.

2. Since microorganisms are present in the foods, storage requirements for them are strictly circumscribed (FDA, 1976). Primarily, this is dependent on adequate refrigeration, although other additional conditions such as modified atmosphere within the package may also be employed. Historically, these foods have not presented a significant public health hazard when they are kept at temperatures below 38° F (3° C). However, large populations of organisms, able to grow at low temperatures, may develop during prolonged storage.

3. Most precooked convenience foods are low-acid foods as defined by FDA (1976), pH >4.6, and are considered to be of higher risk since they do not rely on pH as a means to help control the growth of microorganisms.

4. Water activity is relatively high and is not a substantial factor in the inhibition of microbial growth.

Quality and Safety Requirements

The characteristics listed above for precooked refrigerated convenience foods dictate the major requirements that must be met to assure their quality and safety. *Salmonella*, *Staphylococcus aureus* and *Clostridium perfringens* are the three most common microorganisms that cause meatborne disease in the U.S. (Genigeorgis, 1986 and Tompkin, 1986). However, in properly processed and refrigerated meat products, the growth of mesophilic pathogenic species, the above three plus *Clostridium botulinum* (type A and B), would not be expected. The predominantly psychrotrophic species should be eliminated by a moderate thermal processing step (Buchanan, 1986). The quality and safety of precooked refrigerated meat products can be met if the following criteria are considered.

1. The components used to prepare the food products must have proper and desirable qualities, particularly with respect to flavor, texture, and, of the greatest importance, no preformed, heat-stable microbial toxins or other hazardous by-products should be present.

2. The cooking process must be sufficient to inactivate any bacterial pathogens that might be present. The cooking also should inactivate other vegetative bacterial cells, including psychrotrophs. Boyle (1986) describes several types of pathogenic microorganisms that are associated with meats

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and hence are of concern in meat-based precooked convenience foods. Of the pathogens described by Boyle (1986), *Listeria monocytogenes* has been the most concern during the last year; resulting in various USDA microbiological enforcement actions. The ability of this organism to grow below normally accepted commercial refrigeration temperatures has been the paramount factor in causing alarm among all segments of the food industry, including regulatory agencies and consumers. We should be aware that it is possible for a foodborne pathogen to emerge that can withstand pasteurization temperatures and yet be psychrotrophic. Such developments emphasize the need for industry to continue vigilance in microbiological food safety.

3. Precooked food products must be lowered to an acceptable storage temperature quickly after cooking. Breidenstein (1986) stated a simple rule to obtain a good shelf-life for meat products, "Keep it clean and keep it cold." He suggested that all unfrozen meat products should be maintained at temperature in the 28° to 32° F range to obtain adequate shelf-life.

4. After the cooking and cooling process, the food must be handled properly to avoid contamination. This must be accomplished during cooling, slicing, filling, etc. There should be a minimum of "hands-on" operations, and every effort should be made to use techniques which guarantee that microbial re-contamination is avoided.

5. Packaging of the food must take place with careful sanitary precautions. Equipment and utensils must be sanitized and subsequently protected from re-contamination. Many convenience foods are cooked and then packaged. These foods are subject to post-processing contamination by pathogens and hence are a serious threat to human health (Glass & Doyle, 1989). Although *Salmonella* will not grow at safe refrigeration temperatures (i.e., <38° F), even one microbe present is considered an adulterant by USDA. Johnson (1986) cited a study by the Center for Disease Control which reported that the number of annual cases of human salmonellosis is rising.

The food processing environment is important in the prevention of post-cooking contamination and has too often been ignored as a source of contamination during the packaging process. Air, condensates and aerosols constitute potential sources of microbial contamination in foods during the packaging operation. Packaging materials must be selected that are properly manufactured, distributed and stored to prevent them becoming a source of contamination.

6. Storage and distribution of packaged foods must include proper refrigeration and delivery within safe time limits. Shelf-life of a refrigerated food is limited and should be accurately determined for each refrigerated precooked convenience food. Too often, shelf-life is based upon market pressure rather than carefully conducted studies to obtain factual data. The consumer expects to purchase products that are acceptable to the end of their predicted shelf-life period. It is important to provide package protection for the prevention of unwarranted product abuse during the storage and distribution phases (Lechowich, 1988).

The Undoing of Food Quality and Safety

The foregoing discussion actually concerns information that is well established in the food processing industry. Therefore, our concern regarding the quality and safety of these foods is based on the following points in response to this question:

1. At any point in the chain of events leading to the "moment of consumption," there are possibilities for human errors. Some of these can be identified as the most probable error that will be committed, while others will be unexpected. The methods to assist in the prevention of human error are all too obvious, but it is usually a case of failing to follow established procedures and/or inadequate training and supervision of personnel.

Table 1 summarizes mishandling of meat and meat products by place of mishandling (Genigeorgis, 1986). Mishan-

Table 1. Factors that Contributed to Outbreaks of Meat and Meat Products, by Place of Food Mishandling — Summary of 68 Outbreaks from Table 3 Citing Such Data.

Contributing factor	No. of Outbreaks			Total	%
	Homes	Foodservice	Meat processing plant		
Undercooking	12	14	5	31	46
Improper cooling of cooked foods	8	14	1	23	34
Unsanitary handling practices	2	9	—	11	16
Ingesting raw products	10	—	—	10	15
Preparing a day or more before serving	2	7	—	9	13
Carrier handling cooked food	2	6	—	8	12
Improper thawing of raw foods	—	7	—	7	10
Cross-contamination of cooked foods from raw foods	—	3	1	4	6
Improper curing	3	—	1	4	6
Inadequate heating	2	1	—	3	4
Improper fermentation	1	—	1	2	3
Long preparation time	—	1	—	1	2
Improper cleaning of utensils	—	1	—	1	2
Using toxic plant seeds as spices	1	—	—	1	2

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dling at the meat processing plant was responsible for seven outbreaks appearing in surveillance reports for the U.S. (1978-1984) and Canada (1980-1984). Of the seven, four were due to undercooking of the meat products (Genigeorgis, 1986)

2. Confirmation of innovative processes/products by applied research has been inadequate. This indicates that we have not properly used knowledge available for preventing problems in convenience foods (Conner et al., 1989). For example, commercially precooked roast beef caused repeated episodes of salmonellosis in the early 1980's. This problem was solved by extensive thermal process studies in combination with the prevention of cross-contamination from raw to cooked beef (Genigeorgis, 1986). However, it was well known prior to the introduction of rare roast beef that this problem had the potential to manifest itself. The research should have been done before rather than "after the fact." Numerous other references exist in the literature describing illnesses associated with precooked convenience foods (CDC, 1989; Johnson, 1986).

3. It is well known that precooked convenience foods have undergone spoilage for lack of discipline in following established procedures. We know that usually this involves insults to the food in the form of improper refrigeration, damaged packages, extended shelf-life, etc. These can be prevented by developing sound Standard Operating Procedures (SOPs), quality control programs, and personnel training courses for each food process—all part of the management approach, commonly known as Hazard Analysis Critical Control Point (HACCP system) (Bauman, 1990).

Avoiding Unexpected Problems

In view of the concerns just noted, microbial problems with refrigerated precooked convenience foods can be avoided or minimized by the following actions:

1. The use of the HACCP System throughout food production, processing, and distribution can provide extremely valuable surveillance to minimize hazards associated with any food; and particularly with precooked convenience foods. In early 1990, the USDA announced their intention to review with meat and poultry processors a plan to implement the use of the HACCP system in all facilities under their jurisdiction (Bauman, 1990; Corlett, 1989; Bacus, 1988). However, for HACCP to be successful, intensive training of plant personnel will be essential; a responsibility of corporate management.

2. For the HACCP method to succeed, systematic and judicious samplings and analyses of the product must be performed. These steps must no longer be regarded as frivolous or unnecessary, but an essential part of the successful production of any food product. The costs of administering HACCP will be far less than those associated with foodborne illness outbreaks and/or product recalls.

3. Consumers must assume their rightful responsibility in caring for foods that have been properly manufactured and distributed. In order to accomplish this goal, the food industry must take the initiative in launching new and more vigorous consumer education programs on how to handle, prepare and store food products to assure that microbial illnesses are prevented. Public educational information agencies, espe-

cially those associated with university extension services, must increase their emphasis in educating consumers on how foods can be protected once they are purchased.

4. Product and process innovations must be verified in a thorough and reliable manner prior to the marketing of foods to assure that they do not create a microbial hazard.

Research on Safety/Shelf-Life

Research to improve safety and extend the shelf-life of precooked convenience foods must be continued and expanded. Certainly any innovations or changes in existing processes must be thoroughly investigated to ascertain that a safe product will result before production and marketing are initiated. Some areas of potentially beneficial research are:

1. Development of improved environment sanitization procedures will help assure that the environment surrounding food processing and packaging is not a source of product contamination.

2. New research on product composition can also be expected to provide additional food safety and extend shelf-life. It is also likely that there will be new developments in the innovative control of Aw. The incorporation of the "hurdle technology" concept will drive this anew (Leistner, 1989).

3. One of the very promising areas in this field is the use of live but non-growing cultures of bacteria, such as the friendly lactobacilli. Such cultures have been used successfully in the manufacture of various dairy and meat products. Certain of these cultures are known to be antagonistic to bacteria identified as food-borne pathogens, as well as to bacteria that are associated with the spoilage of such foods (Daeschel, 1989). These friendly bacteria are considered as GRAS ingredients and are safe for use.

4. Lysozyme, a naturally-occurring enzyme in human mucosa, tears, eggs and milk, has been recommended for use in certain foods to destroy *Listeria* (Wilson, 1988).

5. In addition to the use of modified atmospheres in food packages (McMullen and Stiles, 1989; Hotchkiss, 1988), improved packaging and packaging materials will be introduced (Dillon, 1989) and must be thoroughly tested prior to market applications.

6. We will also see improvements in process control that will include better product handling with more easily cleaned equipment and possibly improved post-packaging pasteurization methods. The use of robotics in sterile environments will be forthcoming, for the post-heat handling and packaging of refrigerated convenience foods.

7. The greatest promise for future product acceptability and shelf-life will be dependent on the contributions from and interactions among a combination of these factors to inhibit the growth of microorganisms, i.e., the hurdles concept (Scott, 1989). The safety and shelf-life of convenience foods will be dependent on the use of multiple hurdles that minimize the entrance or survival of dangerous microorganisms in the foods (Scott, 1989; Leistner, 1989). These hurdles must be incorporated into the foods because it is impossible to manufacture convenience foods with a guarantee that no pathogen can gain entrance. Even hospital operating rooms cannot guarantee absence of pathogens during surgery! (Ready, 1990).

Can the foregoing factors solve all our present or future

problems? Certainly their proper application could eliminate or minimize our present problems. As new foods and processes are developed, it will require the integrated efforts of the following groups to assure food safety for the consumer: 1) food technologists; 2) research microbiologists; 3) research chemists; 4) regulatory personnel; 5) quality testing laboratories. The collaborative efforts of these professionals should be sought before a new food is marketed.

Future Challenges

Some challenges that the future may present are:

1. Demographics will undoubtedly continue to affect new food developments even more than they have in the past. As the average age increases, new foods will be developed for the geriatric segment of the population.
2. The centralization of food processing will continue and this will have marked effects on the demands for assuring food quality and safety over extended shipping distances and storage times.
3. Food distribution channels will lengthen and require careful attention to the quality and safety of the foods during distribution and storage periods.
4. The volume and variety of convenience foods will continue to increase. As the number of working couples continues to increase, convenience foods will find new and more extensive markets (Sills-Levy, 1989).
5. Dziezak (1990) summarized a lecture by Hudson, wherein he noted that food processors can expect increased scrutiny due to new consumer expectations of convenient products. Customer resistance to chemical preservatives cannot be expected to decrease. As a result, alternative preservation and safety assurance developments will be required, such as cook-in-bag and hot-filled products.
6. New food products, especially fabricated meat items, will be developed, many of which certainly are not on the drawing boards as of this date.

Each of the foregoing will impact with different severity on the microbial quality and safety of the convenience foods.

Future Microbial Problems

Dare we to predict the types of microbial problems that might confront us in the future? We foresee problems with:

1. Emerging Pathogens — Microorganisms that are not now easily or routinely monitored may well be a future concern. *Campylobacter jejuni* and *Yersenia enterocolitica* are two of the so-called emerging pathogens of particular concern and they are cited in numerous sources in the literature (Boyle, 1986; Lechowich, 1988;). Their importance may be dependent on the use of new sources of raw products as well as environmental factors that will allow the bacteria to gain entrance to food processing areas. We are now experiencing the presence of *Listeria* in different foods. Johnson et al. (1990) reported a low incidence of *Listeria* in the interior portion of whole-muscle roasts. This finding indicates that undercooked meat could contain *Listeria monocytogenes* and as we fabricate new products from muscle meats, we distribute the pathogens.

The AMI *Listeria* monitoring program of ready-to-eat meats in 1987 and 1988 showed that frankfurters (Table 2) were a

Table 2. AMI *Listeria* Monitoring of Ready-to-eat Meat Products.

Samplings	Number of Samples	Positive Samples			
		25 GMS		1 GM	
		No.	%	No.	%
1987					
All Products	87	10	11.5	4	4.6
All Plants	22	10	45	4	18
Plant A	3	2	66	1	33
Plant B	6	3	50	1	17
1988					
Frankfurters	21	8	38	5	24
Luncheon					
Meat	25	1	4	1	4
Ham	9	1	11	1	11
Miscellaneous	22	0	0	0	0
All Products	77	10	13	7	10

likely carrier of *Listeria monocytogenes*. As a result, the meat industry needed to tighten process controls (Wilson, 1988).

2. Viruses that are known to originate in food animals may also become a problem in foods. As methods for their detection become available, we may find this to be a significant problem. Blackwell (1987) concluded that more research is necessary in order to determine the viral disease transmission rate through foods.

3. Unrecognized toxins may be identified as new analytical procedures are developed. These toxins may originate in the food during its production or may be allowed to develop by microbes that are in the food.

4. Heat-stable enzymes may become more of a problem as new convenience foods are developed. It is known that certain enzymes are formed by microorganisms, but are not a problem in the short shelf-life that is currently used for foods. However, these enzymes can withstand temperatures used to sterilize foods and can then cause undesirable changes in food quality during storage of the processed and packaged food.

Such enzymes have been identified as a major problem with ultra high temperature sterilized milk, intended to have a shelf-life of at least six months. Enzymes formed by psychrotrophic bacteria in the raw dairy product are known to be the source of the spoilage problem in this product. It is possible that some heat-stable enzymes could produce a health hazard.

5. We should be alert to the potential for microorganisms to adapt to new food preservation technologies. Through mutation, microorganisms have shown us that they can adapt to various stresses (environmental, antibiotics) that allow them to emerge under unusual circumstances.

Summary

The purpose of this paper is to alert the food industry, and in particular the meat industry, to concerns paramount to assuring a safe, wholesome food supply when refrigerated precooked convenience foods are offered in the market-

place. The public can be expected to become more dependent on food manufacturing industries for their daily meals and the consumer has every right to expect the industry to supply safe, tasty and nutritious products. Furthermore, the general philosophy of regulatory agencies must be to provide essential surveillance to assure that such foods are provided.

The food industry, in turn, is challenged with responding to three major concerns, viz. (1) the need to use what we

already know; (2) the need to conduct adequate research and verification testing on existing and new processes/products; and, (3) the need to educate the consumer in the care and use of their food products. We maintain that it is necessary to approach the production of this new class of foods (refrigerated precooked convenience foods) with the integrated, multi-disciplinary expertise that is currently available to the food industry.

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Discussion

D. Buege: Would you compare the thermal effectiveness of conventional reheating versus microwaveable reheating; and do you think that because of the strong microwave use we are at increased risk in any of these precooked foods?

N. Webb: Dennis, I have certainly not done that. I have followed some of the work of Roger West, Tony Kotula and some of the other people who have worked on this. I think we are taking some risks. Maybe not from the standpoint that the processor is taking the risk; but if the product does reach the

home contaminated to any great extent, then there is the possibility in the microwave of cold areas or spots that are not heated. Of course, the other possibility is that there is enough flora there, such as *Listeria* to cause problems that might be removed if it was heated uniformly. I think we've been inclined as a society to assume that a microwave is a panacea for heating everything, and that it is doing it uniformly. We certainly know it doesn't.