PROCESSING TECHNOLOGIES

# Home Meal Replacements: Food Safety Hazards and Risks

JENNIFER L. JOHNSON*

The term "Home Meal Replacements", referred to in this paper as "HMRs", can refer to a wide range of food products prepared and sold at a variety of establishments, then consumed at home. HMRs may also be referred to as "meal solutions". Many HMRs are familiar to us. These include: take-out food from restaurants, delivered food from restaurants, take-out food from supermarket delicatessens, frozen meals obtained from supermarkets, and foods obtained from convenience stores. Increasing consumer demand for convenient, high quality, "fresh" meals which require minimal at-home preparation is driving the trend towards refrigerated or even hot foods which may be consumed directly, with little or no additional heating. The consumer's buying preference has expanded from single component foods such as take-out fried chicken, to meals composed of several diverse components such as salad, main dish, bread, and dessert. These "newer" types of HMRs include: chilled meals from supermarkets, hot meals from supermarkets, "meal packages" from supermarkets, chilled meals from restaurants, chilled meals from non-traditional retail outlets (including convenience stores, "warehouse" stores, and other stores which have historically not sold perishable meals), and hot meals from non-traditional retail outlets.

*Jennifer L. Johnson, Deibel Laboratories, Inc., 103 South Second Street, Madison, WI 53704.

*Reciprocal Meat Conference Proceedings, Volume 50, 1997.*

It is difficult to make broad generalizations about the food safety hazards associated with HMRs since the different types of HMRs vary so much. Also, since HMRs may be prepared in a variety of establishments, the safety of a particular HMR entree may be influenced by the site of preparation. In some cases, the HMR may be prepared by a company having long experience in the production of similar foods. In other cases, the HMR may be produced by a company with absolutely no experience in food preparation. Food safety, then, will be largely reflective of differences in food handling environments and equipment and, especially, knowledge of proper food handling practices among food preparers.

I would like to preface my presentation by stating that we have very little food safety information on many of the newer types of HMRs. The HMRs with which we are historically most familiar, TV dinners and delivered pizza, have seldom been implicated in food-borne illness. Safety concerns associated with other HMRs include hazards associated with institutional food preparation **and** hazards associated with home preparation and consumption. Equally important are the expanded opportunities for temperature abuse afforded by a variety of purchasing, storage, and consumption scenarios. In short, we are familiar with the food safety hazards which **might** be associated with HMRs, but assigning risks to various types of HMRs will be a very difficult undertaking. Since we have so few food safety data on HMRs, my presentation will focus on hazards rather than risks. Also, I have chosen to concentrate on microbiological rather than chemical hazards.

## Hazards and Risks Associated with Foods

Epidemiologists differentiate between hazard and risk as follows. A hazard is something which is potentially injurious or dangerous to human health. Risk, in contrast, is the likelihood or probability of the occurrence of a particular hazard. We can identify hazards but we can only estimate risks.

Hazards and risks associated with HMRs will vary depending on: food source, preparation methods, preparation environment, conditions during storage and display, and the interval between heating and consumption. Food-borne disease investigations and surveillance programs have identified food handling practices commonly associated with food-borne illness and have found that the relative importance of these practices varies with the site of food preparation (Figure 1; Bryan, 1988; Bean et al., 1990; Bean and Griffin, 1990). Improper food handling practices identified at food-service establishments include improper cooling, a time lapse (≥12 hours) between preparation and consumption, infected food handlers, inadequate reheating, and improper hot holding. At the home-preparation level, contaminated raw foods, inadequate cooking, foods obtained from an unsafe source, improper cooling, and a time lapse between preparation and consumption are linked to illness.

Microbial physiology and pathogenicity dictate which food borne pathogens are likely to be associated with certain improper food handling practices. Pathogens such as *Bacillus cereus*, *Clostridium perfringens*, *Salmonella*, and *Staphylococcus aureus* are commonly linked to improper storage or food holding temperatures and/or preparation in advance of serving. In contrast, inadequate cooking may lead to illnesses caused by *Clostridium botulinum*, *Trichinella spiralis*, *Vibrio* spp., and *E. coli* O157:H7. Cross-contamination between raw and ready-to-eat (RTE) foods may result in illnesses caused by *Campylobacter* sp. or *E. coli* O157:H7. Trichinosis due to infected pork, *Cyclospora* infections, viral gastroenteritis due to consumption of raw shellfish, and cases of seafood-induced intoxication are examples of illnesses linked to foods from an unsafe source. Poor hygiene on the part of the food handler may lead to illnesses caused by *Shigella*, Hepatitis A virus, Norwalk virus, or *Giardia*.

### Public Misperceptions

The public perception is that millions of pathogenic organisms are necessary to cause illness. While this may be true of historically-important pathogens such as *C. perfringens* and *S. aureus*, the infectious dose associated with other pathogens may be very low. In the Pacific Northwest *E. coli* O157:H7 outbreak, for instance, our best estimate is that contaminated hamburger patties may have contained as few as 40 to 193 cells (Johnson et al., 1995). Similarly, low levels of *Campylobacter* and some strains of *Salmonella* may also cause illness. There is no question that sporadic, low level contamination of HMRs or HMR components has the potential to result in large outbreaks of food borne illness.

Historically, our food supply has been local in origin and distribution has been limited by geographical distance. Today, however, our foods come from various regions of this country as well as from a variety of foreign countries. Products processed in one region of the country may be distributed in a number of states distant from the food's origin, often under a variety of brand names. Also, a contaminated food ingredient may be used as a component in a variety of other foods. These factors make it possible for contaminated foods to cause illnesses in a number of states–illnesses which may not even be recognized as sharing a common origin. In 1989, for instance, *Salmonella*-contaminated mozzarella cheese produced in Wisconsin was linked to illness in several other states (Hedberg et al., 1994). Illness was attributed not only to the contaminated cheese from Wisconsin but also to other cheeses shredded by four large Midwestern processors which handled the contaminated cheese.

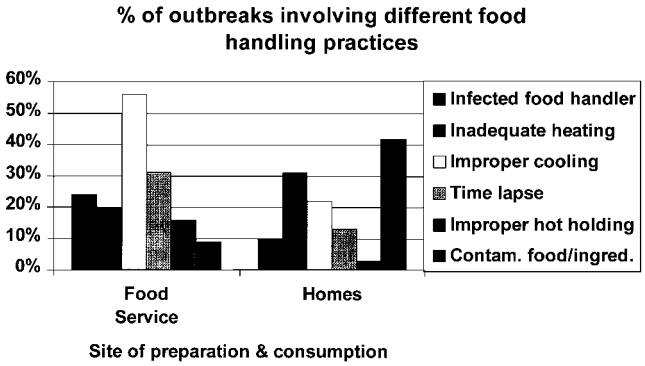
## Food Safety Concerns - HMRs

All of the food safety concerns associated with commercially prepared or home-prepared foods also apply to HMRs. Some additional concerns are also applicable to HMRs: the extent of heat treatment, consumer understanding of the food, packaging, extended chilled storage, and co-mingling of different food types. Co-mingling of different food types in a packaged meal could lead to cross-contamination from raw to RTE foods. This is a potential problem if the RTE food contains no barriers to microbial growth and the meal is held at temperatures which may allow pathogen growth and/or toxin production.

HMRs may be fully-cooked, partially-cooked, or uncooked. Obviously, these different classifications of HMRs require different at-home preparation procedures. However, there is always the possibility that the consumer will misunderstand label directions regarding storage or heating. There are several documented outbreaks of botulism attributed to the consumer's failure to follow label directions to "keep refrigerated" (Trevejo, 1995). In one instance, clam chowder, vacuum-packaged in a plastic bag, was obtained from the refrigerated case in a supermarket, then stored at room temperature for one month by the consumer!

Packaging of HMRs, especially in combination with extended refrigerated storage, is an important consideration because it impacts the consumer's ability to detect spoilage. For example, modified-atmosphere packaging is unlikely to negatively impact any of the major food-borne pathogens but may inhibit growth of spoilage organisms. This could result in a consumer eating a product which was not detectably spoiled but which contained large numbers of pathogens. If a food is held under refrigeration for several weeks, *Listeria monocytogenes* is of primary concern. For foods which have been subjected to mild temperature abuse (e.g. 50°F or 10°C), *Salmonella*, *S. aureus*, or pathogenic *E. coli* may also be of concern. Another potential problem is the consumer's tendency to associate certain types of packaging with shelf-stability. A cardboard box containing a foil-laminate pouch of stew, for instance, may be associated in

**FIGURE 1.**




*Food handling practices associated with outbreaks. Adapted from Bryan, 1988.*

the consumer's mind with shelf stability since many cardboard-packaged foods are stored at room temperature.

## Sequence of HMR Events

A typical sequence of events associated with an HMR might be as follows: preparation; display; transport from point of purchase to consumer's home; preparation at home; consumption; and handling of leftovers.

### Preparation

HMRs may be prepared in a variety of settings ranging from continuously inspected USDA-FSIS plants to occasionally-inspected FDA plants to seldom-inspected restaurants or sandwich operations to rarely-inspected convenience stores. In any of these preparation sites, multiple processes may be occurring simultaneously. For example personnel in some supermarkets may go from taking raw shellfish out of the case to steaming the shellfish to scooping RTE deli foods into containers. These sorts of scenarios make it almost impossible to generalize about the types of preparation-specific hazards which may be encountered with HMRs. One must consider not only the hazards unique to a particular food, but also the hazards attendant to any other foods being handled at the same time in the same facilities.

Proper preparation of HMRs involves: proper facilities; use of safe foods/ingredients; proper food handling practices including proper cooking, prevention from cross-contamination or re-contamination, prompt and proper chilling, good personal hygiene, and good equipment and environmental sanitation; and prompt packaging. Two of these concerns are of paramount importance: proper facilities and education in good food handling practices. I am aware of several facilities being used for food preparation which lack the space and separate equipment needed to adequately separate RTE products from raw foods. It is not a surprise that none of these facilities was originally designed for food preparation!

It is possible to argue that the lack of food-service knowledge at supermarkets, convenience stores, and other non-traditional food outlets may have a negative impact on the safety of foods prepared at those sites. For instance, untrained personnel may be unaware of the need to wash produce in sinks separate from those used for washing poultry. Similarly, the importance of using disposable towels instead of rags or sponges for cleaning up spills may be lost on untrained food handlers.

One hazard which is difficult to control is the transmission of pathogens to food by food handlers experiencing episodes of diarrhea and/or vomiting. Cases of food-borne illness attributed to a number of pathogens (including *Salmonella*, Norwalk virus, *Giardia*, and *Shigella*) have been linked to sick employees with poor personal hygiene practices (Hedberg et al., 1994). It is also possible for humans to excrete pathogens such as *Salmonella* and Hepatitis A without showing any evidence of infection, "Typhoid Mary" being the most notorious example of this (Molenda, 1990). In the absence of good personal hygiene habits, this situation has been known to result in outbreaks of food-borne illness.

### Display at Point of Sale

Safety at the point of sale relies largely on maintenance of the proper temperature (usually refrigerated), proper case packing, and intact packaging. These measures are necessary in order to prevent the growth of mesophilic pathogens, slow the growth of psychrotrophic pathogens, and prevent contamination. Display case temperatures of 30 to 34°F (-1 to 1°C) are recommended, but case temperatures often exceed these levels. Delicatessen displays are often subject to the poorest control; Daniels (1991) reported that 96.5% of products were above 37°F (3°C), 82.5% above 40°F (4°C), 55.6% above 45°F (7°C), and 12.9% above 55°F (13°C). Foods stored in overloaded refrigerated cases and/or displayed above the "fill line" may experience temperatures high enough to permit microbial growth.

Display design and case sanitation are important means of preventing cross-contamination which may be associated with display of HMRs. It is critical that raw foods be separated from RTE foods, especially if the RTE foods are in bulk and must be portioned out by in-store personnel. Another means of preventing cross-contamination is to restrict the use of raw vegetable garnishes and decorative plastic dividers. All too often, garnishes and decorative dividers are moved indiscriminately between raw product cases and cases containing RTE foods.

Finally, the possibility of pathogen growth during display means that displayed product should be properly rotated. Although the "best by" or "expiration" date typically refers to spoilage and not safety, the date does provide some information about length of storage. Out-of-date food should always be discarded, never mixed into a new batch. Recycling outdated foods may result in sizeable numbers of microorganisms being inoculated into freshly-prepared foods; this can negatively impact safety if the old product contains pathogens.

### Transportation

Transportation of HMRs from the point of purchase to the home can impact the safety of these foods. Since HMRs sold at supermarkets are typically refrigerated or frozen, the ideal situation would be for consumers to select frozen and refrigerated foods just prior to entering the check-out line at the supermarket. However, the design of most supermarkets makes this unlikely because the refrigerated and frozen display cases are typically located at the back of the store with the check-out lines at the front. Protecting RTE foods from raw foods is a consideration often overlooked when groceries are being bagged. It is important that raw foods (especially muscle foods) not be allowed to drip onto RTE foods because this can result in pathogen contamination.

Extended holding periods at ambient ("room") temperature may permit growth of pathogens present on HMRs and other foods. Ideally, refrigerated or frozen food should be maintained in a refrigerated condition until it reaches the home and is placed in the refrigerator or freezer. A British study (Worsfold and Griffith, 1997) reported that 45% of consumers transported chilled food at ambient temperatures sufficiently high to raise the food temperature above 47°F (8°C). Obviously, it is desirable to minimize transportation time, yet we must recognize that this may not always occur in practice.

### Preparation at Home

Since many HMRs are sold refrigerated, temperature control in the home refrigerator is a critical control point. Recommendations are that home refrigerators be maintained at 38°F (ca. 3°C) or below, yet more than 1 out of 4 home refrigerators are held above 45°F (7°C), and nearly 1 in 10 is above 50°F (10°C; Daniels, 1991). Temperature control is especially important since an HMR may be held for extended periods under refrigeration–first at the point of sale, then later in the home.

HMR in-home preparation steps should be aimed at preventing the introduction of pathogens into the food. This amounts to observing good personal hygiene (hand washing!), preventing cross contamination, and maintaining good kitchen and refrigerator sanitation. The sad truth is that many consumers fail to properly wash their hands before handling foods. Consumers are slowly becoming aware of kitchen sanitation issues, but many still do not realize that sponges and dishcloths may be contaminated with pathogens (Enriquez et al., 1997).

### Consumption at Home

Hazards associated with consumption of HMRs relate to time delays between preparation and consumption and holding conditions during these time periods. Once heated, foods should be consumed immediately but studies have indicated that 60% of consumers delay consumption (Worsfold and Griffith, 1997). Typically, delays in consumption result in the foods being held at room temperature for extended periods, with periods in excess of 2 hours not being uncommon. Nearly one-third of Americans surveyed recently admitted to eating take-out foods more than 2 hours after purchase and to holding those HMRs without refrigeration (Nagle, 1997). With pathogens such as *C. perfringens* having generation times of 10 minutes or less, it is easy to understand why extended ambient temperature storage is a bad idea!

### Handling Leftovers

As noted above, holding fully-cooked HMRs and other RTE foods at ambient temperature is a common consumer behavior. In fact, the practice of "cooling" cooked foods on the counter top before refrigerating them is disturbingly common. Consumers often fail to realize how important it is to place leftovers into shallow containers and place those containers in the refrigerator so that cold air may freely circulate around them. It is critical that leftovers be thoroughly chilled as quickly as possible in order to prevent pathogen growth on the still-warm food.

Leftover food and, especially, "doggie-bag" food should always be consumed as soon as possible (preferably within 2 days). The combination of handling and temperature abuse favors pathogen growth on leftovers which lack "hurdles" to microbial growth. Since heating reduces levels of competitive microflora, any pathogens present on the food are (more or less) free to grow unimpeded until temperatures become limiting. As a result, more pathogens may be present on temperature-abused cooked food than would be found on the corresponding raw food. This is one reason why it is so important to reheat leftovers until all portions reach at least 165°F (74°C). Since microwaves are often used for reheating leftovers, it is important that consumers be aware of the unevenness of microwave cooking and the need to let food stand after removal from the oven.

## Knowledge Issues

Any discussion of food safety hazards associated with HMRs **must** address a general lack of food safety knowledge amongst both consumers and food handlers. There is widespread awareness of the need to educate everyone in food safety, but this awareness has yet to be translated into action. Food safety education programs aimed at commercial food handlers have been developed by a number of trade organizations (including the National Restaurant Association and the Food Marketing Institute) and universities. These programs have traditionally addressed hotel, restaurant, and institutional food handlers. Less effort has been directed towards educating non-traditional food handlers such as convenience store employees and supermarket delicatessen personnel. In many instances, food handlers have no more knowledge of proper food-handling practices than does the average consumer. The remainder of this paper will use the term "consumer" but the comments apply equally to uneducated food handlers, regardless of site of employment.

By a number of measures, it is apparent that food safety information is either not reaching consumers or not being absorbed by them. For example, only 18% of consumers reported washing or disinfecting counters, cooking areas, or utensils after contact with meats (Farquhar, 1997). Further, consumers typically fail to differentiate between microbiological safety issues and spoilage issues (Williamson et al., 1992). Consumer knowledge of the extent to which raw foods are contaminated with pathogens is also minimal. For example, many consumers do not realize that cut melons can transmit *Salmonella* despite the fact that at least 5 such outbreaks have occurred in recent years (Tamplin, 1997). Consumers may not realize that refrigeration is incapable of controlling food-borne pathogens such as *L. monocytogenes* and *Yersinia enterocolitica*.

Surveys have indicated that consumers often misperceive the nature and origin of food-borne illness and fail to associate home food-handling practices with food-borne illness (Fein et al., 1995). This may be a consequence of the common media portrayal of food safety being determined by food manufacturers rather than by food preparers. Without the realization that food preparation behaviors impact food safety, it is unlikely that consumers are going to pay much attention to information on proper food-handling practices.

## Conclusions

The microbiological safety of HMRs reflects the amount of care taken throughout preparation, display, and consumption to prevent pathogen contamination and prevent or restrict microbial growth. There is little doubt that HMRs have the potential to result in large, widespread outbreaks of food borne illness due to mass production and widespread food distribution. The phenomenon of mass food preparation and the potential for contamination of RTE foods by food handlers with poor personal hygiene means that illnesses caused by viruses, *Shigella*, and pathogenic *E. coli* may become more prevalent. Not only are these pathogens infective at low levels, but temperature abuse by the consumer would increase the hazard associated with the bacterial pathogens. A multitude of consumer HMR-abuse scenarios has the potential to result in an increase in the number of sporadic cases and/or small family outbreaks of food-borne illness. The fact that these potentials exist, however, does not mean that they will be realized. Time will tell.

## References


Bean, N.H.; Griffin, P.M. 1990. Food borne disease outbreaks in the United States, 1973-1987: pathogens, vehicles, and trends. J. Food Protection 53:804-817.

Bean, N.H.; Griffin, P.M.; Goulding, J.S.; Ivey, C.B. 1990. Foodborne disease outbreaks, 5-year summary, 1983-1987. J. Food Protection 53:711-728.

Bryan, F.L. 1988. Risks of practices, procedures and processes that lead to outbreaks of foodborne diseases. J. Food Protection 51:663-673.

Daniels, R.W. 1991. Applying HACCP to new-generation refrigerated foods at retail and beyond. Food Technol. 45(6):123-124.

Enriquez, C.E.; Enriquez-Gordillo, R.; Kennedy, D.I.; Gerba, C.P. 1997. Bacteriological survey of used cellulose sponges and cotton dishcloths from domestic kitchens. Dairy, Food and Environmenal Sanitation 17:20-24.

Farquhar, J.W. 1997. Home meal replacement. Presentation given at 50th annual Reciprocal Meat Conference, Ames, IA.

Fein, S.B.; Jordan Lin, C.-T.; Levy, A.S. 1995. Foodborne illness: perceptions, experience, and preventive behaviors in the United States. J. Food Protection 58:1405-1411.

Hedberg, C.W.; MacDonald, K.L.; Osterholm, M.T. 1994. Changing epidemiology of food-borne disease: a Minnesota perspective. Clin. Infect. Dis. 18:671-682.

Johnson, J.L.; Rose, B.E.; Sharar, A.K.; Ransom, G.M.; Lattuada, C.P.; McNamara, A.M. 1995. Methods used for detection and recovery of *E. coli* O157:H7 associated with a food-borne disease outbreak. J. Food Protection 58:597-603.

Molenda, J.R. 1990. Tracking down "Typhoid Mary". Dairy, Food and Environmental Sanitation 10:602-606.

Nagle, M. 1997. When good foods go bad. Prevention magazine 49(8):86-95.

Tamplin, M. 1997. Salmonella and cantaloupes. Dairy, Food and Environmental Sanitation 17:284-286.

Trevejo, R.T. 1995. Foodborne outbreaks in California, 1993-1994. California Morbidity #19/20. Reprinted in Dairy, Food and Environmental Sanitation 15:611-615.

Williamson, D.M.; Gravani, R.B.; Lawless, H.T. 1992. Correlating food safety knowledge with home food-preparation practices. Food Technol. 46(5):94-100.

Worsfold, D.; Griffith, C.J. 1997. Assessment of the standard of consumer food safety behavior. J. Food Protection. 60:399-406.