MIROIL

Addendum A

Food Borne Pathogens

Included in the Addenda are:

1. An analysis of heat delivery to food – a brief look at why oil temperature alone does not deliver heat to food centers; and how MirOil antioxidants do provide efficient cooking performance at lower temperatures that are less damaging to the oil.
2. A summary of the issue of pathogens by Dr. Bielska

   Food borne diseases are on the rise. These bacteria are present in the environment and even in our bodies. For example, E. Coli is prevalent in our own intestinal flora. Salmonella is found throughout our environment.

   I am sure you are already aware, the key to killing these bacteria is to cook the food thoroughly. Getting the food to a safe internal temperature is not difficult. However at higher temperatures, while killing the pathogens, you are "killing" the oil.

   A constant dilemma is to avoid diminished cooking performance as the composition of the oil is degraded.

   An equal challenge is to avoid over cooking the food. You want to always serve succulent, crisp food that is free of these biologicals.
3. A copy of an article on E. Coli from Clinician Reviews, a professional journal for Medical Professionals.

   This addendum documents the need for thoroughly cooking food.
4. A review article by MirOil, published in the Journal of Lipid Science Technology to document the prindiples of MirOil antioxidant + oil management for Optimum Frying

The MirOil antioxidant is a key part of oil management for Optimum Frying. This simple program enables you to achieve the required internal temperature in your food, and yet, cook at a lower temperature.

Analysis of heat delivery to food

The use of Miroil *fryliquid*™ and *Frypowder*® antioxidants increase heat delivery to food centers

This happens with lower oil temperatures & provides several unexpected and important benefits:

1. **Food cooks faster with extra insurance of a safe temperature of food centers.**
2. **Lower cooking temperatures and faster cooking times reduce formation of acrylamide.**
3. **Lower cooking temperatures and faster cooking times reduce formation of transfatty acids.**
4. **Food absorption is minimized.**
5. **Yield is enhanced with minimal shrinkage.**

Explanation:

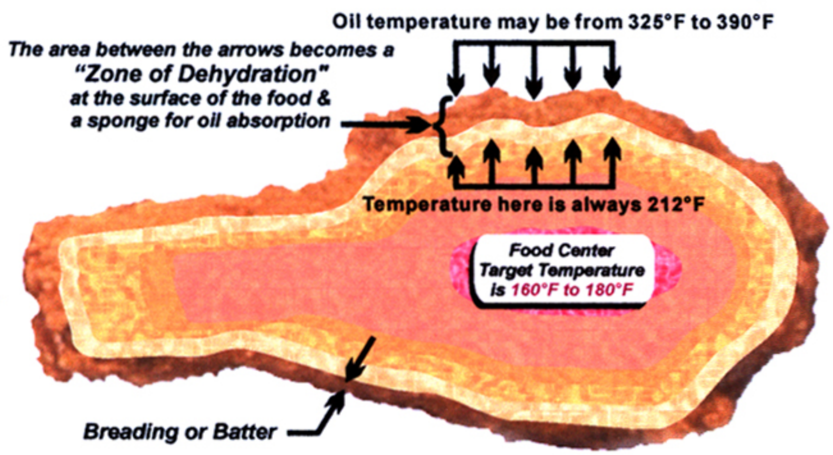
Heat delivered the food is used in 2 ways:

1) to convert water to steam at the surface of the food

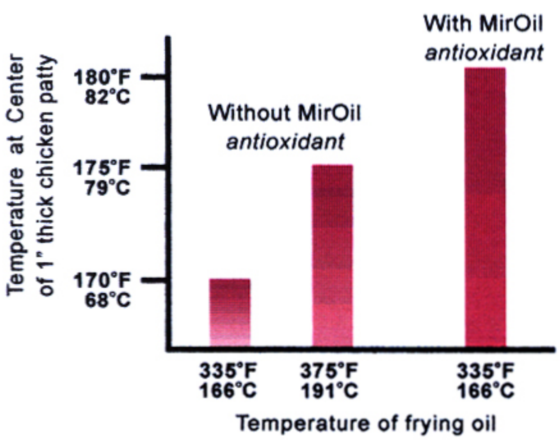
2) to provide thermal energy for cooking food .

This creates a "zone" of dehydration at the surface of the food. The cut away of the chicken leg shows that at the inner border of this dehydrated area, the temperature is always 212°F no matter how high the oil temperature is.

Higher oil temperatures intensifies delivery of heat to the surface of the food.



Heat that would otherwise be available to cook the center of the food is diverted to overcook the surface of the food. This greater heat delivery converts more surface water to steam and delivers less heat to food centers



The bar graph on the left is from a study[1] that confirms *fryliquid*™ and *Frypowder*® antioxidants provides more heat delivery to food centers.

Even though the oil treated with MirOil antioxidant is 40°F lower, the temperature at the center of the food is 5°F higher.

The above "Analysis of Heat Delivery"explains this unexpected result.

Summary of a study by A Philip Handel, Ph. D.,
Bioscience and Biotechnology, Drexel University

Fooborne Diseases on the Rise

Prepared for MirOil, Division of Oil Process Systems, Inc.
by Barbara Bielska, Ph. D. March 1999

Part I New Antibiotic-resistant bacterial pathogens are emerging

Not only are new pathogens discovered, but pathogens already known, such as E. coli and Salmonella, have turned out to produce new highly toxic, antibiotic resistant strains. E. coli and Salmonella have always been around. Most people never suffered after ingestion of food contaminated with this bacteria or, at worst, they had mild symptoms of food poisoning. New strains of E. coli and Salmonella are much more toxic and to make matters worse, antibiotic resistant.

At least 25 new microbes that can cause food poisoning have been discovered since 1975. For example, hardly anybody had heard of Listeria or Campylobacter 20 years ago. In 1996 a detailed study of food poisoning cases revealed that the most common cause of foodborne illness in the United States is a relatively obscure bacterium, Campylobacter jejuni, found in poultry.

Federal health officials estimate 8 million Americans were poisoned by food last year. The Centers for Disease Control and Prevention say foodborne disease is on the rise nationwide. Estimates are that up to 9000 deaths and from 6,500,000 to 30,000,000 illnesses in the US are caused by foodborne pathogens each year.

Between 400 and 500 outbreaks of foodborne illness occur each year according to the latest statistics from the Centers for Disease Control and Prevention (CDC) in Atlanta.

Across the country, food poisoning outbreaks are bigger and nastier than ever before. Here are just a few numbers illustrating the trend. Since early August 1998, 40 illnesses caused by a single strain of Listeria monocytogenes have been identified in 10 states: Ohio (13 cases); New York, Tennessee, Massachusetts and West Virginia (three each); Michigan (two); and Connecticut, Oregon, Vermont,and Georgia (one each). Four outbreaks of Salmonella in the Kansas City metropolitan area were reported between 1996 and 1998.

> **Case Study A: McFadden, 58, had been successfully operating a Mexican restaurant in West Palm Beach since 1981. On an early August weekend in 1995, however, his success fell apart when nearly 1,000 people became sick from Salmonella contracted at Margaritas within a five-day period. The official cause of the outbreak was cross-contamination; tainted chicken is suspected. Despite the restaurant's insurance company's payment of $825,000 to settle a class-action lawsuit, litigation is still pending against the restaurant.**
>
> **Case Study B: Robert Nugent enjoyed a good life as president and CEO of Foodmaker Inc., the San Diego based parent of more than 1,300 Jack In The Box restaurants. On January 17, 1993 an outbreak of food poisoning in a Seattle restaurant nearly destroyed the whole chain. Three children died and one child, Brianne Kiner, suffered permanent damage. As it turned out, hamburgers tainted with E. coli 0157:H7 were the cause.**
>
> **A flurry of lawsuits landed on the company's doorstep. Six month after the incident, Foodmaker settled a class-action suit filed by franchisees for about $44.5 million, more than double its net income the year before the outbreak. In 1995, it settled a shareholder class-action suit for about $8 million. Nugent moved rapidly to make amends on about 500 claims with victims, including a $ 15 million settlement with Brianne Kiner's family.**

More and more operators fret that they may be in the path of a similar disaster. Outbreaks of food poisoning are relatively rare but like a hurricane, they can destroy a restaurant with swift and sudden force.

According to a Restaurant Business survey, 95% of all operators fear an outbreak of foodborne illness in their restaurant. Only 2% are not concerned about the risk of food contamination. Customers are similarly alarmed and they may have reason to worry.

The CDC estimates that 97% of all cases of food poisoning result from improper food handling; 79% of cases result from food prepared in commercial or institutional establishments; and 21% from food prepared at home. Chicken, eggs and beef are considered high risk foods. The most common causes are:

1. Inadequate cooking or reheating,
2. Leaving prepared foods at temperatures which allow bacterial growth,
3. Cross-contamination.

Part II Recently Emerged Foodborne Pathogens

Escherichia coli 0157:H7:

a new, antibiotic-resistant strain, discovered by the CDC in Oregon in 1982.

Incubation Period: two to four days.

Symptoms: Hemorrhagic colitis, possibly hemolytic uremic syndrome. The acute disease caused by this bacteria is called hemorrhagic colitis and is characterized by the severe damage to the intestinal lining, hemolytic uremia, and permanent loss of kidney function. Mortality rate among the elderly and children who have been infected is as high as fifty percent.

Possible contaminant: Ground beef, raw milk, chicken.

E. coli is found normally in the intestines of healthy animals, including humans. People become ill when they ingest contaminated food. In the past, undercooked hamburgers have been the main source of nearly all outbreaks. In recent years, however, E.coli 0157:H7 has turned up in many kinds of foods and fresh produce.

Steps for prevention: Thoroughly cook meat (internal temp at least 160° F), no cross-contamination.

Listeria monocytogenes:

particularly virulent bacterium found in soft cheese, lettuce and other foodstuffs.

Incubation period: two days to three weeks.

Symptoms: Meningitis, septicemia, miscarriage. Disorders called listeriosis results in various specific conditions including septicemia, meningitis, encephalitis and intrauterine or cervical infections in pregnant women. Listeriosis is characterized by influenza-like symptoms such as fever and/or gastrointestinal symptoms such as diarrhea and vomiting. The worst outcomes tend to occur in pregnant women. Perinatal or neonatal infections have a greater than eighty percent mortality rate for the fetus or infant. Listeric meningitis sufferers have a seventy percent mortality rate and about half of those who contract septicemia will die. Parties at high risk for mortality include the elderly and persons using antacids or cimetidine (tagamet).

Possible contaminant: Vegetables, milk, cheese, meat, seafood. Listeria can be found mostly on raw vegetables and is a particular concern with fresh lettuce.

Steps for prevention: Cook foods properly (internal temperature 160-180°F), pasteurize milk, avoid cross-contamination with use of sanitary practices.

Salmonella thyphimurium DT104:

A new, antibiotic-resistant strain. Salmonella occurs widely in animals, water, soil, and kitchen surfaces.

Incubation period: one to six hours.

Symptoms: Nausea, vomiting, diarrhea and headache, also my result in chronic arthritic symptoms. Recently, a new very virulent and antibiotic-resistant strain has emerged, Salmonella DT104. The strain has been a scourge to both food animals and humans in Europe. It's now spreading in the United States. According to the New England Journal of Medicine, 34% of salmonella cases were DT104 in the US in 1996, compared to 0.6% in 1979-1980.

Possible contaminant: Meat, poultry, eggs or milk products.

Steps for prevention: Cook thoroughly (160°F inside the food), avoid cross-contamination, use sanitary practice.

Campylobacter jejuni:

infection, even with low numbers.

Incubation period: one to seven days.

Symptoms: Diarrhea, abdominal cramps, nausea, headache, Campylobacter is the number one cause of foodborne illness in the US. This bacterium can result in a rare autoimmune disease in adults called Guillain-Barre syndrome, which attacks nerve tissue and may cause temporary paralysis and chronic nerve-related abnormalities. C. jejuni is estimated to cause death in one of every 1000 cases.

Possible contaminant: Raw milk, poultry, eggs, raw beef, cake icing, water. Campylobacter is most often associated with poultry products. Raw or undercooked chicken is by far the most common cause of infection. A study at the University of Georgia found that 41 percent of student stool cultures yielded Campylobacter. The major risk for infection was identified as eating chicken.

Stops for prevention: Pasteurize milk, cook foods properly, (especially chicken should be cooked thoroughly, internal temperature should reach 160°F), prevent cross-contamination.

Cyclospora:

a new, very virulent bacteria, first identified in 1989. It has been found on raspberries, basil, lettuce.

Part III Reasons for the Increase in Outbreaks of Foodborne Pathogens

There are many reasons for a nearly threefold increase of microorganisms known to cause food illness since 1975:

1. Greater consumption of imported foods,
2. The trend towards factory farms and mass production,

   The food industry has consolidated mass processing operations, causing a situation in which a single virus or bacteria can quickly infect a large number of animals. A typical hen house in 1945 contained 500 birds. According to the CDC, today, many houses contain 100,000 hens, and multiple houses are linked by common machinery.

   The United States Department of Agriculture temporarily shut down some or all operations at 34 meat and poultry plants during the first three months of 1998 because of contamination or dirty and unsafe conditions, according to the Wall Street Journal.

3. The evolution of antibiotic-resistant bacteria.

   This last cause is due to the addition of antibiotics to animal feed. Antibiotics, used to aid growth in animals, also help create drug-resistant strains of bacteria. Nearly one third of all antibiotics produced in the US are combined with animal food to encourage animal growth.

According to CDC predictions new pathogens will continue to emerge. This dangerous trend is inevitable. The HIV and ebola viruses are a part of this trend.

The restaurant owners, unfortunately, can not rely on the poultry industry for delivering a bacteria free product. In a study performed in 1997 in US, 63 percent of 1000 store bought chickens were contaminated with Campylobacter, while 16 percent were contaminated with Salmonella.

Part IV Prevention

An important factor in proper meat and fish handling is to make sure that it is cooked thoroughly. This basically means that the temperature in the center of the food must be from 160°F to 180°F. It is understood that all foodborne bacteria will die at 160°F. Some sources recommend 180°F as the temperature which gives total assurance that all bacterial pathogens are killed.

In the case of fried food thorough cooking is easy to achieve. Food fried in a good oil that is reasonably fresh for an appropriate cooking time is likely to be safe. However food infected with bacterial pathogens which are fried in older and abused oil is more likely to be unsafe.

The cooking characteristics of abused and oxidized oil cause much more heat to be apportioned to quickly over cook outside surfaces of the food while the center receives a much lesser portion of the heat. The result is the center of food cooked in older oil is often undercooked.

Meat that is partially raw, especially chicken, has a serious potential to be very hazardous.

MirOil has developed Frypowder oil stabilizer as part of a frying oil management program. The program has been proven to maintain the condition of the oil like "seasoned" fresh oil. More heat is apportioned to food centers so they are not undercooked and food surfaces are not over cooked. Food fried in oil maintained according to MirOil protocol is always horoughly cooked with center temperatures high enough to kill hazardous bacteria.

Prevention is the key to avoiding or abating infection from foodborne diseases. Employ good sanitary practices to avoid cross contamination.

References:

1. *From the Center for Disease Control and Prevention. Update: Multi-state outbreak of listeriosis. United States, 1998-1999., JAMA. 1999 Jan 27;* **281***(4), 317-8.*
2. *Stephenson J., Worry grows as antibiotic-resistant bacteria continue to gain ground, JAMA. 1997 Dec 17;* **287***(23), 2049-50.*
3. *Breuhaus B., Proceed With Caution: Awareness of food safety is at an all-time high for food operators, Restaurant Business Magazine, July 1, 1998, No. 13, Vol.* **97,** *Pg 27.*
4. *Chavich C., Raw chicken carries high risk, Calgary Herald, March 1, 1998, Sunday, Final Edition, Section Food; Pg E8.*
5. *Common Fodborne Pathogens, Food Safety Project, Iowa State University Extension, 1997-98.*
6. *Deliganis C.V., Death by Apple Juice: The Problem of Foodborne Illness, the Regulatory Response, and Further Suggestions for Reform, Food and Drug Law Journal,* **53**, *681, 1998.*
7. *Smith N. F., Germ alert: infectious diseases lurk everywhere; are we really in danger? Summer Safety Guide, Ladies Home Journal, July, 1998.*
8. *Lance B., The rise of foodborne illness; CrossReach, Restaurant Hospitality, May, 1997, No.5, Vol.* **81,** *Pg. 156.*
9. *Wilkinson T. H., Griffin R. G., Warlen A.A., Hershley M., Hoff G. L., Salmonella outbreaks in the Kansas City metropolitan area; varying presentations, Kansas City Department of Health, Missouri, USA, Mo. Med. 1999, Feb;* **96***(2), 62-6.*
10. *Bloomberg, Drug-resistant strain of Salmonella spreading, The Gazette (Montreal), May 7, 1998, Thursday, Pg.A18.*
11. *Waters J., Back in the Black, Restaurants & Institutions, July 1, 1998, No.16, Vol.* **108***; Pg 42.*

Clinician Reviews
July, 2002

E coli O157:H7: an emerging bacterial threat. (Board Review).

Author/s: Joseph Faiella-Tommasino

Though called hamburger disease by some, Escherichia coli O157:H7 infection can be contracted through consumption of contaminated water, unpasteurized milk and fruit juices, and tainted fruits and vegetables, especially sprouts--in addition to undercooked ground beef. Most dangerous in the youngest and oldest patients, E coli Ol57:H7 infection can lead to acute life-threatening systemic conditions (hemolytic uremic syndrome, thrombotic thrombocytopenic purpura) and/or chronic health problems (eg, cardiomyopathy, pulmonary damage, and end-stage renal disease). Care of the patient infected with E coil O157:H7 is largely supportive, so prevention through patient education is essential.

Among the hundreds of known strains of the gram-negative bacillus Escherichia coli, most are not only harmless, but beneficial: They colonize the intestines of healthy humans, suppressing the growth of pathogenic bacterial species. However, several strains of so-called enterohemorrhagic E coli have emerged in recent years. The first such serotype to be identified was E coli O157:H7, a potentially deadly strain capable of causing severe gastroenteritis and possibly life-threatening complications. (1)

The E coli 0157:H7 bacillus is associated with the consumption of contaminated water and several foods, particularly those of bovine origin (ie, beef, particularly ground beef). Contact with infected people (eg, handling contaminated fecal matter without thorough hand washing) and with livestock has also been implicated. Infection with E coli O157:H7 is most common in the summer months, (1) when warmer ambient temperatures may promote its spread.

Since 1982, when the serotype E coli O157:H7 was first identified in the stool samples of American patients with bloody diarrhea, (2) it has evolved from a clinical novelty to a global health concern. Human infection with this pathogen has been reported in more than 30 countries on six continents. In the United States and Canada alone, 65 outbreaks have occurred. (1) More than 20,000 US cases are reported annually, and at least 250 are fatal. (3)

THE SOURCES

Potential sources of infection vary. Among the most highly publicized outbreaks, one involved consumption of undercooked hamburgers in a fast-food restaurant chain in Washington State, Idaho, California, and Nevada in 1992 and 1993 (4); similar outbreaks in Washington and Oregon in 1993 were attributed to cross-contamination from meats to salad bar items (5); in October 1996, three outbreaks in the Midwest and one outbreak in the Northeast were traced to unpasteurized apple cider (6); and in a severe outbreak affecting hundreds in Sakai, Japan, in 1996, radish sprouts were implicated. (1,7)

In New York State alone, about 200 cases of infection with E coli O157:H7 occur annually. Probably the largest waterborne E coli outbreak in US history occurred there in August 1999, with 1,000 confirmed cases apparently contracted at the Washington County Fair. Torrential rain followed by runoff of cow manure from a nearby cattle farm contaminated well water--the source of tap water at the fair, used to make ice, lemonade, and frozen desserts. (8)

Thus, the majority of E coli O157:H7 outbreaks are associated with consumption of contaminated water and of undercooked ground beef (hence the Canadian designation hamburger disease (9)); of unpasteurized milk or apple cider (6,10); and of fruits and vegetables contaminated in some way. Ground beef, it has been suggested, is most likely contaminated during slaughtering and processing. (1,10) Apple cider is most likely contaminated by manure through use of "drop apples" or other contact; because the acid-tolerant E coli 0157:H7 bacillus can survive as long as four weeks, adding preservatives to cider may not reliably kill the organism. (6) In the category of fruits and vegetables, sprouts (eg, alfalfa, clover) may pose the greatest hazard, since trace amounts of pathogens in the seed apparently multiply during sprouting. (7)

PRESENTATION

After a postexposure incubation period averaging three to four days (range, one to eight days (1)), severe abdominal cramping and watery diarrhea begins. E coli O157:H7 infection is characterized by rapidly progressive bloody diarrhea; bowel movements may be composed entirely of blood. (3,10) (On the other hand, the illness may initiate as non-bloody diarrhea, making it difficult to differentiate from the acute viral gastroenteritis commonly seen in children. 911)) Nausea, vomiting, and a low-grade fever may be present. Physical assessment may reveal dehydration, generalized petechiae, and edema from fluid shifting out of the vascular beds. (3,10)

Once noninfectious conditions are ruled out and a pathogenic bacterium is strongly suspected, it becomes important to rule out other infectious agents (see Table 1 (1)). The constellation of signs and symptoms of diarrheal illness--whatever the responsible pathogen--may be similar. Routine stool cultures do not differentiate the E coli O157:H7 strain from normal enteric flora, and most clinical laboratories do not routinely screen for this pathogen. Cultures may also be reported as negative or inconclusive if they are performed 48 hours or longer after onset of symptoms. (12)

Thus, stool samples must be collected well within that time frame and tested specifically for E coli 0157:H7. Sorbitol-MacConkey agar is reliably used to screen stools for E coli 0157:H7; unlike most other E coli, the O157:H7 serotype forms colorless colonies in this culture medium. (1)

It is important to note that the abundant organized mucosal epithelial cells lining the appendix may attract E coli cytotoxins to this tissue. Thus, appendicitis is a potential complication of E coli O157:H7 infection. (1,13)

Potential Systemic Complications

Many cases of enterohemorrhagic E coli O157:H7 are self-limiting. However, the process of E coli O157:H7 invasion is complex: adherence of the pathogen to the small-bowel mucosa, direct invasion of mucosal cells, and disruption of the microvillus brush border, followed by release of cytotoxins. (10)

These toxins, known as Shiga toxins, verocytotoxins, or verotoxins, inflict significant injury to the intestinal epithelium and may invade the underlying vasculature. (12) As recent

Treating Systemic Complications Management of confirmed HUS requires meticulous attention to fluid and electrolyte balance, nutritional support, treatment of severe anemia, and control of hypertension, seizures, and azotemia. Kidney dialysis may be required in as many as 50% of cases. (1,3) A renal biopsy can determine the extent of kidney damage, which is the best indicator of prognosis. Systemic involvement, however, is an indicator of poor prognosis.

Elderly patients who are treated conservatively for HUS/TTP have a reported mortality rate of almost 90%. (17) In a 1996 outbreak of E coli O157:H7 infection in Scotland, older patients who developed HUS/TTP were treated with therapeutic plasma exchange (intravenous fresh frozen plasma and immunoglobulin G) to counter coagulopathy and help boost their immune systems against the debilitating complications of E coil O157:H7 infection. The mortality rate in treated patients was reduced to 45%. (17)

Unfortunately, this procedure is expensive and invasive. Also, its use (particularly in older adults) is associated with pulmonary edema, as well as hypocalcemia and hypomagnesemia--which can cause arrhythmias. (3,17)

PREVENTION

Preventing E coli O157:H7 infection is difficult because the pathogen colonizes the intestines of healthy cattle and other animals that provide food for humans. E coli 0157:H7 is resistant to acidic conditions, dehydration, and high salt concentrations. A toxoid vaccine may become available in the future; for now, however, conscientious control through local public health authorities is the mainstay of prevention.

Health care providers can help prevent E coli O157:H7 infections by cautioning their patients against eating undercooked meat or drinking water from unsafe sources or unpasteurized milk or juices. Other preventive strategies include proper food handling-meticulously washing surfaces and utensils that may have been contaminated by uncooked meat, thoroughly cooking ground beef (to an internal temperature of 160[degrees]F), and carefully washing fruits and vegetables. Those who handle or prepare foods, change soiled diapers or dispose of fecal matter, or have contact with farm animals should wash their hands frequently and thoroughly to prevent infections and spread of existing infection. (23)

Persons who have been infected with E coli O157:H7 should also wash their hands often. After E coli O157:H7 infection, children should not return to day care, nor health care workers or food handlers to their respective places of employment, until they are asymptomatic and have had two negative stool cultures. (23)

Health care providers should immediately inform public health authorities when they see an unusual number of patients with diarrhea or bloody diarrhea, when E coli 0157:H7 isolates have been identified, or when they notice an increased incidence of HUS. (1)

CONCLUSION

Although current fears about bioterrorism could focus on E coli O157:H7 infection (see "E coli O157:H7 as a Biological Weapon?" (24-27), other pathogens are probably better candidates for bioterrorist weaponry. In any event, E coli O157:H7 poses a significant threat to human health worldwide. If contact on some level is unavoidable, it is clear that surveillance for E coli O157:H7 infections must improve, along with our understanding of its research suggests, enhanced thrombin generation and impaired fibrinolysis severely compromise blood flow to the kidneys, the brain, and other organs (14,15)--and, in extreme cases (often in the youngest and oldest patients (1)), result in systemic complications: hemolytic uremic syndrome (HUS) and/or thrombotic thrombocytopenic purpura (TTP). (16)

In both of these potentially life-threatening conditions, patients experience microangiopathic hemolytic anemia (ie, fragmentation of red blood cells) and thrombocytopenia. (1) However, patients with HUS have acute renal impairment, while TTP patients experience neurologic signs and symptoms (17) (including confusion and memory loss). Infection with E coli O157:H7 has been determined to be the most common cause of HUS in the United States and the leading cause of acute renal failure in children. (3) Typically diagnosed six days after onset of symptoms of E coli O157:H7 infection, HUS may develop in as many as 15% of infected children in North America. (18)

In older persons, HUS and TTP may overlap or even be considered the same disorder. (1,17) Patients with either condition may experience hemoglobinuria, oliguria, or anuria. (3,10,12)

Between 10% and 15% of patients with HUS/TTP develop long-term effects, including cardiomyopathy, pulmonary problems, pericardial effusions, end-stage renal disease, chronic hypertension, chronic pancreatitis, cholelithiasis, colonic stricture, hyperglycemia, and encephalopathy. (1,3) In about one fourth of patients, acute neurologic complications (eg, stroke, seizure, coma) develop. (1)

TREATMENT

Until E coli O157:H7 infection is ruled out, patients should be treated as if they have it. Patient care is largely supportive. Fluid intake and output must be closely monitored. If serious dehydration should occur, fluids and electrolytes must be replaced to prevent acute renal failure. Patients should not be given anti-motility drugs (eg, loperamide, diphenoxylate with atropine) because their use is associated with development of HUS and potentially severe neurologic symptoms. (3) Strict medical control of hypertension is essential to prevent secondary vascular damage during recovery. (3,19)

Peripheral blood smears, hematocrit levels, and urinalysis must be monitored for possible progression to HUS--specifically, serum markers of thrombin activation and fibrinolysis and urinary markers of renal tubal injury. (14,15) Clinicians should routinely monitor the frequency and characteristics of stools, check the perianal area for signs of skin breakdown, and auscultate and document bowel sounds.

Use of antimicrobial agents to treat E coli O157:H7 infection is considered controversial. (1) Some researchers have suggested that antimicrobials increase the release of toxins from the intestine for absorption throughout the body; this could increase the patient's risk of developing HUS. (20) In one study, children treated with antibiotics for E coli O157:H7--related gastrointestinal infections were found seven times more likely than others to develop HUS. (18,21) Yet in a Japanese trial conducted after the outbreak in Sakai, patients given fosfomycin within three days of illness had an overall lower risk for developing HUS than did those treated later or not at all. (1)

Other medications under study include synthetic verotoxin trisaccharide receptors (22) and low-dose antithrombotic agents. (14,15) Understanding the pathogenetic mechanisms of E coli O157:H7-produced toxins is expected to spur the development of future treatment options.

epidemiology. Primary health care providers must educate their patients in strategies to avoid E coli O157:H7 infection--and react promptly and effectively when exposure occurs.

ESCHERICHIA COLI O157:H7

Infectious agent	Escherichia coli serotype O157:H7, a gram-negative, rod-shaped bacterium that produces verocytotoxins(Shiga toxins)
Incidence	In developed countries, five to eight cases per 100,000 population annually; regional variations. In the United States, most commonly reported in Connecticut, Minnesota New York State, and Oregon
Risk groups	Children younger than 5 years and adults older than 65; imunocompromised persons and gastrectomy patients
Transmission	Principally, ground beef and raw milk; also untreated water, unpasteurized cider and juices, venison and other game meat, dry-cured salami, plant foods fertilized with raw manure, lettuce and sprouts, mayonnaise, and cheese curds. Person-to-person transmission possible through inadequate hygiene
Presentation	Acute bloody diarrhea, abdominal cramps lasting five to 10 days; little or no fever
Complications	Hemolytic uremic syndrome, thrombotic Thrombocytopenic syndrome
Treatment	Supportive (fluids and elecrolytes as needed), with monitoring for dehydration, hypertension, and signs of complication. Anti-motility agents are contraindicated; use of antibiotics is controversial

Sources: Centers for Disease Control and Prevention, US Food and Drug Administration, National Foundation for Infectious Diseases.
Table 1

ESCHERICHIA COLI O157:H7 INFECTION DIFFERENTIAL DIAGNOSIS (1)

Noninfectious conditions	Infectious agents
Intussusception	Campylobacter
Ischemic colitis	Salmonella
Gastrointestinal hemorrhage	Shigella
	Cryptosporidium
Inflammatory bowel disease	Isospora
	Yersinia

REFERENCES

(1.) Mead PS, Griffin PM. Escherichia coli O157:H7. Lancet. 1998;352:1207-1212.

(2.) Riley LW Remis RS, Helgerson SD, et al. Hemorrhagic colitis associated with a rare Escherichia coli serotype. N Engl J Med. 1983;308:681-685.

(3.) Mackenzie DL. When E. coli turns deadly. RN. 1999;62(7):28-32.

(4.) Centers for Disease Control and Prevention. Update: Multistate outbreak of Escherichia coli O157:H7 infections from hamburgers--western United States, 1992-1993, MMWR Morb Mortal Wkly Rep. 1993;42:258-263.

(5.) Jackson LA, Keene WE, McAnulty JM, et al. Where's the beef? The role of cross-contamination in 4 chain restaurant-associated outbreaks of Escherichia coli O157:H7 in the Pacific Northwest. Arch Intern Med. 2000; 160:2380-2385.

(6.) Centers for Disease Control and Prevention. Outbreaks of Escherichia coli O157:H7 infection and cryptosporidiosis associated with drinking unpasteurized apple cider--Connecticut and New York, October 1996. MMWR Morb Mortal Wkly Rep. 1997;46:4-8.

(7.) Mohle-Boetani JC, Farrar JA, Werner SB, et al. Escherichia coli O157 and Salmonella infections associated with sprouts in California, 1996-1998. Ann Intern Med. 2001;135:239-247.

(8.) Charatan F. New York outbreak of E coli poisoning affects 1000 and kills two. BMJ. 1999;319:873.

(9.) About CPKDRC [the Canadian Pediatric Kidney Disease Research Centre]. Available at: www.cheori.org/cpkdrc/about_cpkdrc.htm. Accessed June 7, 2002.

(10.) Weir E. Escherichia coli O157:H7. CMAJ. 2000;163:205.

(11.) Fitzpatrick M. Haemolytic uraemic syndrome and E coli 0157: prevention rests with sound public health measures [editorial]. BMJ. 1999;318:684-685.

(12.) Kaminstein DS. E. coli O157 infection. In: Gale Encyclopedia of Medicine. 2nd ed. Detroit, Mich: Gale Group; 2001.

(13.) Murch SH. Diarrhoea, diagnostic delay, and appendicitis [commentary]. Lancet. 2000;356:787.

(14.) Chandler WL, Jelacic S, Boster DR, et al. Prothrombotic coagulation abnormalities preceding the hemolytic-uremic syndrome. N Engl J Med. 2002;34623-32.

(15.) Grabowski EF. The hemolytic-uremic syndrome--toxin, thrombin, and thrombosis [editorial]. N Engl J Med. 2002;34658-61.

(16.) Centers for Disease Control. Epidemiologic notes and reports: thrombotic thrombocytopenic purpura associated with Escherichia coli O157:H7--Washington. MMWR Morb Mortal Wkly Rep. 1986;35:549-551.

(17.) Dundas S, Murphy J, Soutar RL, et al. Effectiveness of therapeutic plasma exchange in the Lanarkshire Escherichia coli 0157:H7 outbreak. Lancet. 1999;354:1327-1330.

(18.) Wong CS, Jelacic S, Haheeb RL, et al. The risk of hemolytic-uremic syndrome after antibiotic treatment of Escherichia coli O157:H7 infections. N Engl J Med. 2000;342:1930-1936.

(19.) Sheff B. Escherichia coli (E. coli) 0157.H7. Nursing. 1999;29(5):25.

(20.) Walterspiel J, Ashkenazi S, Morrow A, Cleary T. Effect of subinhibitory concentrations of antibiotics on extracellular Shiga-like toxin I. Infection. 1992;20:25-29.

(21.) Warning to parents: E. coli and antibiotics don't mix. FDA Consumer. 2000;34:7.

(22.) Armstrong GD, Rowe PC, Goodyer P, et at. A phase I study of chemically synthesized verotoxin (Shiga-like toxin) Pk-trisaccharide receptors attached to chromosorb for preventing hemolytic uremic syndrome. J Infect Dis. 1995;171:1042-1045.

(23.) Centers for Disease Control and Prevention, Division of Bacterial and Mycotic Diseases. Escherichia coli O157:H7. Available at: www.cdc.gov/ncidod/dbmd/diseaseinfo/escherichiacoli_g.htm. Accessed June 10, 2002.

(24.) Kolavic SA, Kimura A, Simons SL, et al. An outbreak of Shigella dysenteriae type 2 among laboratory workers due to intentional food contamination. JAMA. 1997;278:396-398.

(25.) Torok TJ, Tauxe RV, Wise RP, et al. A large community outbreak of salmonellosis caused by intentional contamination of restaurant salad bars. JAMA. 1997;278:389-395.

(26.) Centers for Disease Control and Prevention. Biological diseases/agents listing. Available at: www.bt.cdc.gov/Agent/Agentlist.asp. Accessed May 23, 2002.

(27.) Tucker JB. Historical trends related to bioterrorism: an empirical analysis [special issue]. Emerging Infect Dis. 1999;5:498-504. Available at: www.cdc.gov/ncidod/EID/vol5no4/pdf/tucker.pdf. Accessed June 12, 2002.

RELATED ARTICLE: E COLI O157:H7 AS A BIOLOGICAL WEAPON? (24-27)

In the past 40 years, instances of deliberate contamination with shigella or salmonella have been reported in Japan, Oregon, and Texas. (24,25) Since the engineered anthrax outbreaks following the terrorist attacks of September 11, 2001, the potential threat of bioterrorism has raised significant concern. Agents to fear include anthrax, smallpox, and yersinia--all listed among Category A biological diseases and agents by the Centers for Disease Control and Prevention (26) and, among food safety threats listed in Category B, Salmonella and Shigella species in super-concentrated forms.

E coli O157:H7, also a Category B agent, has been described as a pathogen easily cultured and readily available. (27) However, it is expected that other pathogens will prove to be hardier and/or easier to deliver, making them more likely candidates than E coli O157:H7 for bioterrorist weaponry.

Joseph Faiella-Tommasino is the Director of the Touro College PA Program, Bay Shore, New York, and works clinically as a PA in a private medical practice in Babylon, New York; he also serves as the battalion surgeon (PA) in the US Army Medical Specialists Corps, Army National Guard, 69th Infantry. Heidi Reigert is a second-year physician assistant student at the Bay Shore PA Program at Touro College.

D 14215
ISSN 1438-7697
EJLST 501-600 (2000)
Vol. 102 · No. 8-9

8-9/2000

European Journal of Lipid Science and Technology

Official Journal of the German Society for Fat Science (DGF)

Special Issue:
3rd International Symposium on Deep-Fat Frying – Optimal Operation

WILEY-VCH

Eur. J. Lipid Sci. Technol. **102** (2000) 560–565

Bernard Friedman

Technical Director,
MirOil – Division of Oil
Process Systems Inc.,
Allentown, USA

Adsorbent antioxidant provides optimum frying in restaurant and fast food fryers

Frying fats and oils have a finite and relatively short useful life. The sensory quality of the food diminishes until the oil is discarded. With traditional frying practices there is a "dilemma to choose" when the oil has reached the end of its useful life because of diminished food quality and/or legal restrictions. This report describes an adsorbent antioxidant product that is able to provide true optimum frying where the sensory quality of food and oil is consistent and high. Wasted oil is diminished, the oil absorption of food is reduced, and more heat is delivered to the center of foods while cooking with lower than usual oil temperatures. The formation of carbon and polymer gum deposits on fryer surfaces is arrested. The polar content of the oil is always within required regulatory limits. The underlying principles of oil management with the adsorbent antioxidant provide new insights into the frying process.

Keywords: Frying, filtering, antioxidant, adsorbent, polar.

1 Introduction

Frying is a preferred choice for food production because of flavor and cooking efficiency. As the fresh oil is "seasoned", the food quality immediately peaks with the formation of some degradation products. At this time the food cooks with a preferred light golden finish. Polar substances continue to form and accumulate at progressively greater rates causing the food to cook with a progressively darker finish and with progressively increasing oil absorption. Inevitably it is necessary to discard the oil as wasted because of the diminished sensory quality of the food and/or the high polar content. This cycle of oil life is accompanied by a cycle of food quality that repeats endlessly.

Protocols for research to optimize frying have been directed to document a reduction of the rate at which polar substances accumulate in the oil. This will extend the useful life of the oil. With optimum frying as a reality, the goals of research may be refocused toward documenting enhanced cooking "performance" and enhanced productivity of fats and oils as a priority over a longer useful life of the oil.

This report defines what is believed to be true "optimum frying" and discloses the principles of a product and application method to stabilize the composition of the oil and its ability to cook food with high sensory value. This results in the control of the frying process in restaurant and fast food fryers. The principles for the oil management method are based on published research references and unpublished research references available by email inquiry to the author.

Correspondence: *Bernard Friedman*, Technical Director, MirOil – Division of Oil Process Systems Inc., 602-20 N. Tacoma Street, Allentown, PA 18109, USA. Phone: +1-610-437-4618; Fax: +1-610-437-3377; e-mail: bfriedman@nni.com

2 Definition of "Optimum Frying"

When all the many difficulties inherent in traditional oil management are eliminated and oil productivity is optimized, we have the elements for a definition of "Optimum Frying".

The following is a list of important improvements over traditional oil management for the operation of restaurant and fast food fryers:

1. The sensory quality of food is always good or superior.
2. The chemical composition of the oil is always good or superior and never in conflict with regulatory limits of oil use. There is no periodic cycle of "oil life" from fresh to discard.
3. The nutritional profile of food is always high from minimal absorbed oil. From item 2 in this list it follows that both the oil in the fryer and the oil absorbed by the food contain minimal oxidative and thermal degradation substances.
4. The cooking performance of the oil is always good or superior. The delivery of heat to the center of the food is always greater for safer, higher temperatures. Food surfaces do not quickly become overcooked (dark and dehydrated). The oil always cooks the food as if it were lightly used, "seasoned" fresh oil.
5. Fryer and oil management discipline is the same every day and is easy to perform.
6. Fryer surfaces are always free of carbon and polymer gum deposits.

0931-5985/2000/0809-0560 $17.50+.50/0

7. Consumption of cooking oil is reduced.
8. The energy required for cooking is reduced.

"Oil that is always good" is the second item listed under the above definition of "Optimum Frying". Oil with more than 24% polar content or more than 12% polymer triglyceride content is considered wasted (abused oil) according to the 3rd International Symposium in Hagen on March 20, 2000. However, oil is often found with a polar content below 24% and a content of polymer triglycerides below 12% which cooks food with poor sensory quality. This is also unacceptable according to the 3rd International Symposium.

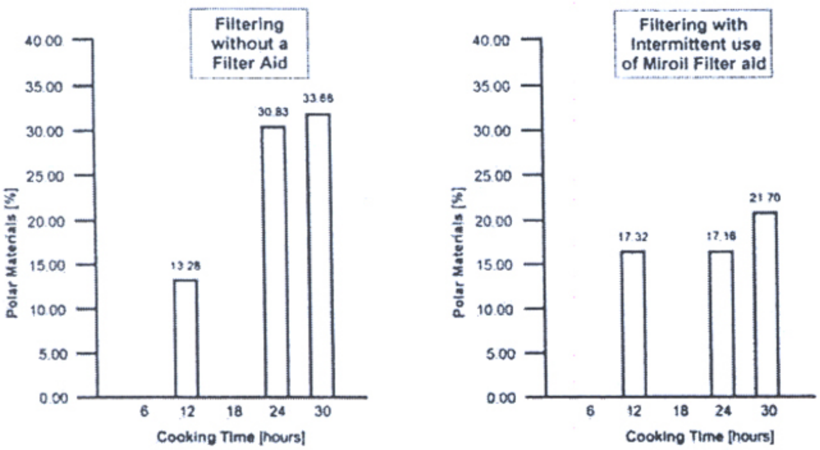
For purposes of this report, "good" oil is proposed to be oil that has a low polar content and will cook food with a good or superior sensory quality. The total polar content must be below 24%. *MirOil* experience suggests that a value below 16% polar content is an important benchmark for optimum frying. Polar substances form at progressively higher rates when the oil has a higher polar content. This can make control of oil composition marginal or unstable.

Any significant deviation from a consistent oil composition is the "end" of optimum frying where "the sensory quality of the food must always be good or superior".

Traditional practice for oil management is to filter periodically with or without a filter aid. Fig. 1 shows the antioxidant filter aid reduces the polar content and thereby increases the useful life of the oil.

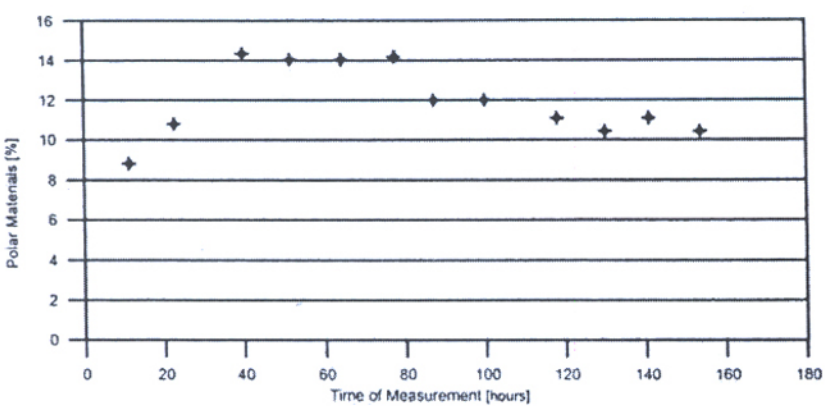
Fig. 2 is a private communication that confirms the oil may have a consistent and unexpected low polar content of only 14% with the "continuous use method" of applying the *Frypowder®* product.

A published studies by *Wingett* et al. [1] and by *Handel* et al. [2] show the comparative performance parameters of the adsorbent antioxidant with intermittent and "continuous" methods of application.



*This data is from a private communication
Dr. C. Gertz, Chemiedirektor Stadt Hagen
Chemisches Untersuchungsamt

Fig. 1. Comparison of no filter aid with the intermittent use method of MirOil filter aid. Each 12 hour frying period. Chicken 3 × 200 g, French Fries 5 × 200 g.



*This data is from a private communication
Dr. C. Gertz, Chemiedirektor Stadt Hagen
Chemisches Untersuchungsamt

Fig. 2. Effect of MirOil filter aid used continuously. Each frying period: fryer oil capacity: 10 litre, French fries: 20 kg/Period, freshening: 4 kg/period, period length: 12 hours, MirOil filter aid added at beginning of each period and hour 6 of each period. Note: The amount of oil for freshening is "equivalent" to 30 hours of oil life.

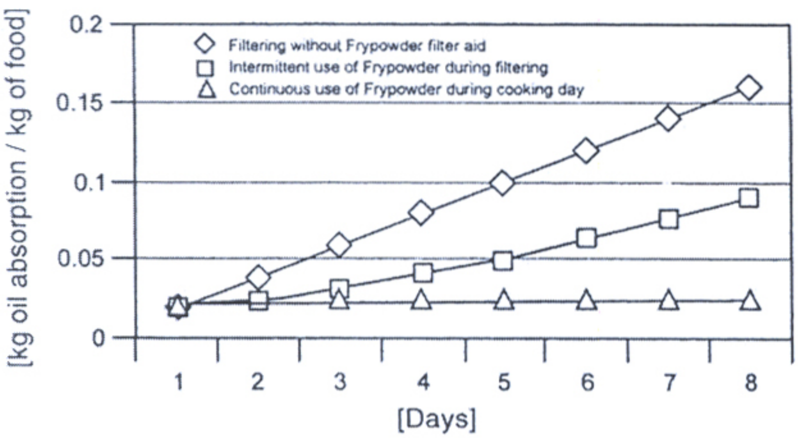


Fig. 3. Comparison of oil absorption. these data are from study references [1, 8].

Fig. 3 illustrates: (i) The antioxidant adsorbent used as part of the filtering procedure reduces food oil absorption as compared to filtering without the product. (ii) Food oil absorption remains at a minimal level when compared to a significant progressive increase in absorption with intermittent or no use of the product.

3 Principles (guidelines) for oil management to achieve optimum frying

There are 3 interdependent and interrelated guidelines for oil management that are the basis for achieving optimum frying. One or more of these management practices may be applied separately to provide only limited improvement in oil performance. There is an unexpected synergy to protect the cooking oil against thermal and chemical decomposition reactions when the 3 principles/guidelines are used in concert. The formation of many oxidative polar substances is arrested. The level of polar substances in the oil is easily stabilized at a preferred low level below 16% polar content.

The 3 guidelines are:

A. "Continuous" application of *Frypowder®* product
B. Cooking at lower temperatures (162 °C to 171 °C)
C. Freshening (daily dilution with fresh oil).

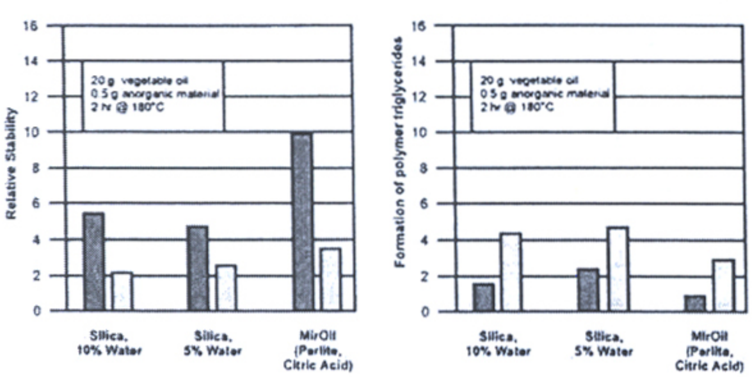
The following paragraphs explain the synergy and efficacy of these 3 principles/guidelines.

A. "Continuous" application of *Frypowder®* product

The *Frypowder®* product has a "continuous" presence in the oil during the entire cooking day. This is a unique method of applying a treatment product to the oil that is covered by US and Euro patents.

The amount of *Frypowder®* product to be used varies with the volume of oil in the fryer. The use instructions have a simple table that specifies the periodic dose. More *Frypowder®* is required when cooking temperatures are higher than specified.

Fig. 4 is a private communication that confirms that *Frypowder®* has a significant antioxidant function. *Frypowder®* is also an adsorbent primarily focused for the abatement of alkaline surfactants. In Discussion it will



*This data is from a private communication Dr. C. Gertz, Chemiedirektor Stadt Hagen Chemisches Untersuchungsamt

Fig. 4. Test for oxidative stability. Addition of anorganic materials to sunflower and rape seed.

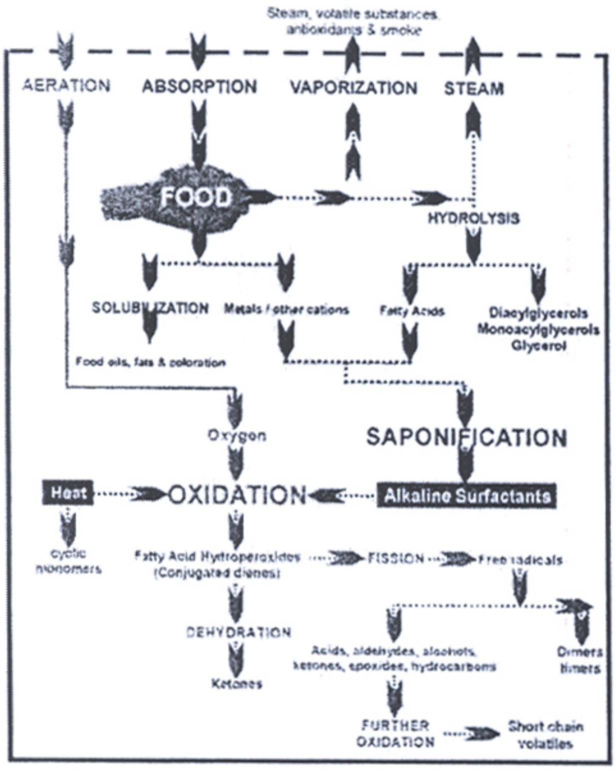


Fig. 5. A schematic of physical and chemical experiences in the fryer. Prepared by *A. P. Handel* to update figure in *Fritsch* [9].

be explained that surfactants enhance food oil absorption and diminish the cooking performance of oil.

Although alkaline surfactants are only a minor component of polar content, their impact on cooking performance is dramatic. The major impact of surfactants is not generally understood. While 1,000 parts per million of alkaline substances is only 1/10th of 1% of polar content, the oil's cooking performance will be diminished as if the polar content were dramatically higher.

Fig. 5 shows that surfactants are products of saponification reactions between fatty acids and metal ions. Another important major source of surfactants, that is often overlooked as a source for degradation of the oil's composition and cooking performance, is the oil present on the surface of precooked frozen food. Private studies show that the quantitative impact of this "imported" oil is very significant and that this oil usually has an elevated surfactant and polar content.

B. Cooking at lower temperatures from 162 °C to 171 °C

Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) [3] reports that alkaline substances rather than free fatty acids (FFAs) reduce the interfacial tension of the oil. We find that when the surface tension of oil is diminished, there is a large increase in the thermal conductivity between the oil and the surface of the food. This creates an unexpected High Temperature Effect (HTE). Fig. 6 illustrates how more intense heat delivery creates a deeper "zone of dehydration" at the surface of the food. When more heat is consumed to convert more surface fluid to steam there is invariably less heat delivered to the center of the food.

Fig. 7 shows the result of an unpublished heat delivery study by *Handel* [10] where the center of a model food is 5 °C hotter for the same cooking time, even though the oil temperature is 23 °C lower.

"As more heat is delivered to the surface of the food, less heat reaches the center of the food". This unexpected heat transfer phenomena is counter intuitive and seems

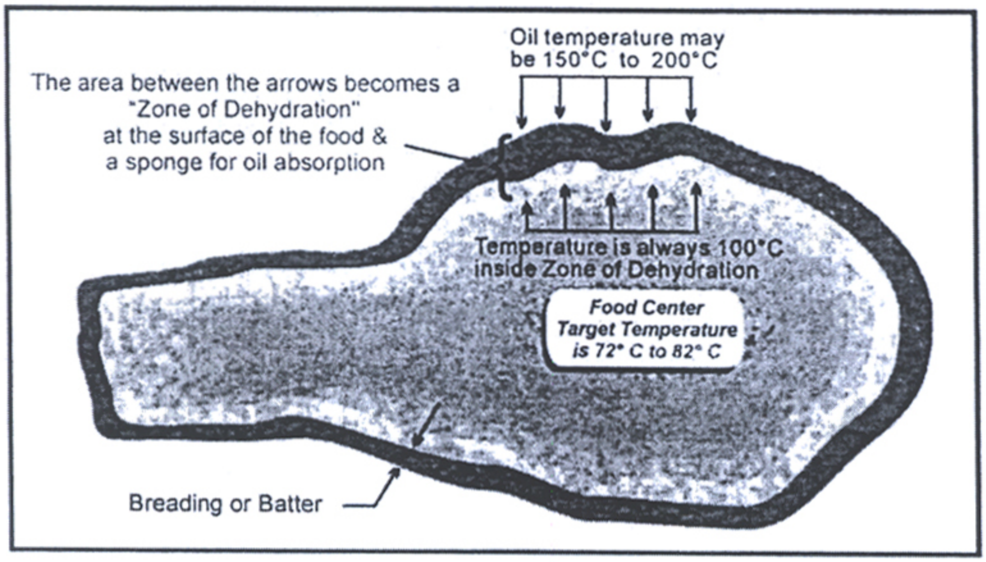


Fig. 6. Study of oil temperature and HTE effect on heat delivery.

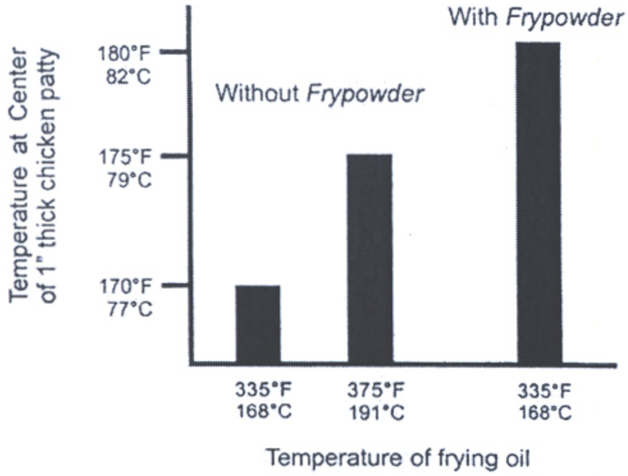


Fig. 7. Study of heat delivery. Temperature of frying oil.

to be contradictory for almost every cook and food technician.

With the abatement (adsorption) of surfactants by continuous use of the *Frypowder*® product, the food cooks just as fast, and often faster, at preferred lower temperatures. The result is more efficient heat delivery to food centers.

C. Freshening

With the application of *Frypowder*® product and the use of lower cooking temperatures, the rate of formation of polar substances in the oil is slowed, but these two practices alone will not prevent the slower buildup of polar content to a critical level in the oil. Freshening, a procedure where some of the old oil is replaced with fresh oil, is required to maintain polar content at a consistent low level. The effect is simple, periodic (daily) dilution to prevent the progressive accumulation of polar substances (also see Tab. 1).

When there is a growing accumulation of degradation products, more degradation products form ever more quickly. This especially applies to the thermally activated oxidative degradation of fats. The reaction is initiated by the formation of free radicals and proceeds as a chain reaction. The typical graph of formation of individual polar substances start with a gentle asymptotic curve and always ends as a ski slope.

Tab. 1. Priority for food quality.

Food quality	"Equivalent" heated life of oil	Oil removed for dilution
Superior	50 hours to 80 hours	20%
Good	80 hours to 100 hours	15%
Acceptable	100 hours to 120 hours	10%

4 The role of filtering

Although there are contrary claims, filtering cannot remove soluble polar substances from the oil. All polar substances pass through the smallest micron size pores of filters because they have a low molecular weight.

The goal of filtering is to make the oil appear to be "clear" and, therefore, perceived to be "good" by the cook. Oil with high clarity can contain a high level of polar substances that are mostly colorless. It is the polar content that undermines both the nutritional profile and the cooking performance of the oil.

5 Safety of the *Frypowder*® product

With the continuous method of application, the product is present in the fryer throughout the cooking day, so there are the obvious questions and equally obvious answers with widespread food use.

The *Frypowder*® product consists of a blend of rhyolitic perlite mineral produced by proprietary process. The perlitic mineral is blended with aqueous citric acid. A comprehensive unpublished review by *Bielska* [4] of the mineral confirms that each element in the mineral composition possesses an absolute certainty of safety.

Sakai and *Nagao* [5] proved the safety of perlite mineral when ingested. Further in a lethal dose $(LD)_{50}$ report [6] *Bankhead* reports "in accordance with the Federal Hazardous Substances Labeling Act Regulations, this product (perlite) is not toxic by oral ingestion and does not require precautionary labeling for oral toxicity".

Does *Frypowder*® migrate to food surfaces? *Handel* [7] studied results of the analysis of blind food samples and confirms that there is no significant increase in silicon due to the continuous presence of *Frypowder*® in the fryer.

Citric acid [4] is blended with the perlitic mineral. Citric acid is widely accepted as a safe oil additive.

Does *Frypowder*® impart flavor to the food or oil? *Frypowder*® applied with the "continuous use method" is found to prevent formation of off-flavors. *Frypowder*® also prevents taste carryover from food to food when used with vegetable oils.

6 Conclusion

The benefits of the "continuous use method" for the *Frypowder*® product are many. Often the fry cook thinks the benefits are too numerous and too good to be true. Optimum frying is feasible and a practical reality. Here again is a summary of benefits not available with traditional oil management products and procedures.

1. The sensory quality of the food is always good or superior.
2. The oil is always within the legal limits for polar content.
3. Oil absorption is minimal.
4. Oil flavor and food flavor is optimal. There is no flavor transfer between different foods cooked with vegetable oils.
5. Less food fluid, including fat, and other food derived substances leach into the oil.
6. Frying is performed at lower temperatures which are less damaging to the oil. Oil temperatures of 163 °C to 172 °C are employed instead of 177 °C to 200 °C.
7. Food centers cook to hotter temperatures within the same cooking time. This may avoid serious health hazards from under cooked food.
8. There is less oil absorbed into the food.
9. The amount of oil discarded is reduced. Experience suggests the overall consumption of oil is reduced from 25% to 40%.
10. Fryer surfaces remain free of polymer and carbon deposits. There is an environmental benefit and a safety benefit from avoiding the need to boil fryer surfaces periodically with caustic to maintain heater efficiency.
11. Because cooking temperatures are lower and less water is driven from the food this allows cooking with less energy.

Acknowledgements

Grateful appreciation is extended to the many people who assisted with discovering and confirming the new understanding of the frying process that added in a large measure to this report.

I especially wish to thank *Christian Gertz, A. Philip Handel,* and *Barbara Bielska* for a number of private communications and unpublished reports included in this contribution.

References

Inquiries for unpublished references may be addressed to bfriedman@nni.com.

[1] *C. Booth, M. Wingett, S. Koch:* Trial of new oil treatment for deep fryers. Food Australia **46(8)** (1994) 372–375.

[2] *D. Naylor, E. McGowan, P. Phengvath, A. P. Handel:* Unpublished study, Adsorbent Treatment of Frying Oil Using Intermittant and Continuous Method. Drexel University, Department of Nutrition and Food Sciences (May 26, 1992).

[3] *L. R. Fisher, E. E. Mitchell, N. S. Parker:* Research Note: Interfacial Tensions of Commercial Vegetable Oil with Water. J. Food Sci. **50** (1985) 1201–1202.

[4] *B. Bielska:* Unpublished study: Health related Properties of the ingredients of Frypowder Oil Stabilizer Product. June 1999.

[5] *T. Sakai, S. Nagao:* J. Toxicol. Sci. **10(2)** (1985) 83–93.

[6] *R. R. Bankhead:* Rosner-Hixson Laboratories: Unpublished LD_{50} report 6/16, 1977.

[7] *A. P. Handel:* Unpublished report: Determination of Residual Frypowder on Fried Food. Drexel University, Department of Nutrition and Food Sciences (May, 1999).

[8] *C. Gertz:* Unpublished study: Stadt Hagen Chemisches Untersuchungsamt, August 1986.

[9] *C. W. Fritsch:* Measurement of Frying Fat Deterioration. J. Am. Oil Chem. Soc. **58** (1981) 272–274.

[10] *A. P. Handel:* Unpublished report: Effect of Frying Temperature and Surfactant Abatement on Cooking Rate of Chicken. Drexel University, Department of Nutrition and Food Sciences (April, 1991).

[Received: June 8, 2000; accepted: July 31, 2000]